SONIFICATION AND ART

DOMINANTE DE LA JOURNEE (KEYNOTE)

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ABSTRACT

After a brief definition of sonification I will discuss two creative approaches – that of Sound design and that of conceptual art. I will attempt to see how these differ and converge in their goals and methods particularly in the context of what we might call musical sonification. I will describe some examples of key sonification artworks and the aesthetic strategies they employ. Finally I will describe *RoadMusic* a project that I have been working on for some time, and the practice to which I apply my ideas concerning sonification.
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It has been suggested in the past that sonification as a term should exclude artistic and musical usage of sound. I am referring here to an article by Sonification expert: Thomas Hermann that can be found in the 2008 ICAD proceedings [10]. In a special edition of AI&Society dedicated to artistic sonification that I guest edited [12], several artists and composers contradicted this position and Hermann himself has revised his point of view since contribution to the review which he co-signs starts with: 'Sonification today is an interdisciplinary practice ranging from scientific applications to sound art and composition [9].'

1. INTRODUCTION

I do not wish to labour a point that has to a certain extent been resolved, however will serve as a starting point for this discussion of the aesthetics and semiotics of sonification. The definition of sonification most commonly cited is that proposed during the ICAD[1] conference in 1999: 'Sonification is the use of non-speech audio to convey information [15]' or in other words the mediation of (most commonly digital) data through sound.

Conveying information through non-verbal sound has a long history. Alerts and alarms ranging from the sounding of the post horn or the chiming of a clock to the warning given by a siren might be considered as precursors to sonification. We can recognise the traits of auditory perception that make it particularly well adapted to these types of signals: hearing is both omni-directional and always available; we cannot close our ears, even when sleeping. And a part from startle responses there are other primitive mechanisms at work, distinguishing variations in multiple streams, without demanding our conscious attention. There are clear advantages in exploiting these faculties in an environment where our visual attention is increasingly monopolized by electronic screens or other technical tasks such as driving.

A well-known example of sonification is the Geiger counter where the frequency of clicks designates the intensity of radioactivity. The nature of the clicking sound of the Geiger counter is the result of its pre-digital electronic circuits, today however, sonification almost inevitably involves choice: that of what sound or which variable parameters of sounds to map to otherwise silent data. Sonifications are pervading our environment and the necessity to distinguish between them is giving rise to complex and sophisticated techniques where analysis of function, and subsequently design, play an increasingly important role. To give another familiar example, a mobile telephone no longer 'rings' but notifies the user by playing a specifically chosen sound, which distinguishes his or her telephone from those of others. It probably plays different sounds for different types of alerts (or even to identify different callers) and beyond this, recent 'smart phones' provide carefully tailored feedback sounds for touch screen functions.

Different principles or techniques of sonification can be identified:

- *Audification* is the direct transposition or transduction of a signal into the audio domain. Audio-biofeedback is an example where sensors connected to a subject's muscles or skull capture electrical impulses that are amplified

[1] International Community for Audio Display

directly and played through a loud speaker as an audio signal. It is also a technique exploited by several artists (myself included) often because it is perceived as being as close as possible to the physical reality of captured phenomena.

- *Mapping Based Sonification* modifies parameters of a sound such as pitch or amplitude. An example is the pulse-oximeter that monitors a patient's blood oxygen saturation as pitch and pulse rate as tempo [20]This is also perhaps the most obvious method for creating musical sonifications since MIDI based, digital music systems are inherently adapted to accept a variable input driven by data.

- *Earcons* are usually short tones, combinations of tones or simple melodies an example might be the jingle preceding an announcement on the PA of a train station.

- *Spearcons* are time compressed speech samples, which can be played at speeds where they are no longer recognizable as words. They represent the advantage of being non-arbitrary, easy to create and easy to learn.

- *Auditory Icons* have a symbolic relation to an action they represent, examples are to be found providing feedback on personal computers, for example: the sound of crumpled paper falling in a waste paper bin used to indicate that a file has been moved to the trash folder.

If we consider these different techniques we might also place them on a scale that goes from direct (almost unadulterated) information through abstracted information to highly symbolized or metaphorical information. Paul Vickers in his 2006 paper *Sonification Absraite/Sonification Concrète: An Aesthetic Perspective Space For Classifying Auditory Displays In the Ars Musica Domain* [24] suggests that we might consider these from the position of electroacoustic music as a slider between Schaeffer / Chion's "reduced listening" and "causal listening". That is to say that within an audification we listen to the purely acoustical properties of the sound and glean information from them. Whereas in the case of an auditory icon we associate the symbolic nature of the sound with a function –mapping based sonification probably fits somewhere between these two. Vickers suggests that musical knowledge is an advantage in sonification design because in a sense it is what composers do all the time.

I would add to this a thought –that comes from friend and fellow composer and sonifier Peter Gena– which is that until very recently music was an affair of data mediation before being one of sound [7]– sound only started to be used in its own right as musical material with the advent of recording and electronically produced sounds. Until then –at least for a long chapter in the history of western music– a composer would right notes (data) to be interpreted by musicians.

2. AUDITORY SCENE ANALYSIS

An approach to sound and musical perception that I have found valuable for sonification design – specifically when there is a situation where multiple sources of information are being sonified- is the Auditory Scene Analysis theory as proposed by Albert Bregman [4]. This considers that there is a primitive aspect of audition, a sorting level so to speak, which is prior to and independent of cultural influences on listening. It is not however the simple reflex/startle response that I evoked above, rather it is a relatively complex mechanism or collection of mechanisms, which have evolved in response to our environment and possibly to our neurological system. It is an intermediary located between the capture of sound through the basilar membrane and the construction of significance through schematic memory and culture. Bregman does not deny the existence of higher 'from the top down' mechanisms, he maintains however that they are built with and on top of a primitive segregation, that he calls 'Auditory Scene Analysis'.

It would be too long here to go into the details of ASA but the basic question to which it provides a response is: How does the ear identify coherent auditory objects from the cross section of incoming sound, the simultaneous mash-up of frequencies? How from the immediate incoming vibrations does our mind distinguish those parts of the frequency spectrum belonging to one source from those belonging to another? If it might seem obvious to us that different sound qualities belong to a same source, from the cognitive point of view it is a complex problem. Each sound we perceive is made up of a multitude of frequency components spread across the spectral range of our hearing, so although we know that the first step in auditory analysis (the cochlea) breaks up the incoming signal into frequency bands, it is unlikely that we are able to identify a sound through this mechanism alone. Bregman demonstrates how principals of gestalt construction apply to sound by using auditory illusions that show how we can be "tricked" into associating elements of the audio spectrum with one another. ASA does not deal with sound objects or even sound sources but rather with 'streams' which can be continuous sounds or repeating sound events (such as notes or footsteps). Bregman studies in great detail the characteristics that tend to group elements such as closeness in time and pitch and those that separate such as non synchronous onset or timbral incoherencies. The interesting thing here is that ASA can provide a method to compose multiple sounds (pitched, musical sounds or other) and predict their interaction (ie what will be considered as separate and what will be grouped as a

same source) even when the sounds are variable and the precise score or mix is unknown in advance. Since ASA mechanisms are pre-cultural using them as a basis for organizing sonification is arguably less risky than a more traditional musical approach that might be misinterpreted by part of the population and since it allows for variation it is possibly richer and less annoying than auditory icons. This last point is important – I argue against the use of recorded samples in sonification applications since (personally) I find repeating sounds rapidly become annoying and if they have the advantage of being unambiguous they are of limited scope in terms of the information they can carry. This might seem to be an argument in favour of audification as a technique and to a certain extent it is – however several non-treated (noisy) audifications might become difficult to distinguish and at the very least require a lot of training or experience to become interpretable.

In the recent symposium I organized on audio mobility Gaëtan Parseihian, researcher at CNRS-LMA, described his research into *The process of sonification design in the case of guiding tasks* [17]. The processes use parameter-based sonification and synthesis to provide feedback information gained via visual capture for (among others) blind people. Gaëtan apologetically explained that blind people where reticent to use the system since a/ in encumbered their (normal) audio perception and b/ they found they the sounds un-subtle and disagreeable. I must admit that I sympathize, for instance I found the sound attached to the reversing sensor on the car I was driving last week, efficiently understandable but insultingly oversimplified and disagreeable in its texture. I would argue that while there is a case to be made for the clear transmission of information through sonification and that it is important to be able to distinguish between different sound sources, it is arguably not always useful to oversimplify and over filter incoming data, and that in certain cases at least alternatives to auditory icons, earcons or rudimentary mapping based sonification can be preferable. There are undoubtedly different ways to approach this problem, I will return to the solutions that I have adopted later.

3. ARTISTIC PROJECTS

Up until this point I have been discussing questions related to sonification design; that is to say the art of crafting sounds for a certain purpose or to mediate certain data in an appropriate way. However there is a different approach possible to the art of sonification, which involves considering the holistic artistic approach that evolves when projects, rather than responding to a design problem, adopt sonification as the means to artistic ends. In these situations, often it is the source of the data itself that becomes significant and the relationship between that source, the situation and the artists mediation that makes the art work. In many cases, these are in a conceptual continuum with the ideas and techniques developed by composers of the mid twentieth century who sought the emancipation of (their) music in regards to (their) expression. I am thinking here in particular of John Cage –his inclusion of the everyday into the compositional process and his definition of experimental music as a being of a kind which the composer discovers at the same time as the other auditors [5]– but also of Stockhausen, Xenakis and the serialist composers who gave *process* a dominant role in composition. Moving on in time I would also include Murray Schafer [19] and others involved in soundscape listening and sound installation, which tend to shift the focus away from the composer's imaginary projection and towards a decision making process that includes real-time and real-place. Digital technology makes this emancipation all the more feasible since it can mediate the everyday, render audible the imperceptible or anchor artistic form in real-time and in real-place.

3.1. Beyond Expression

There is a recurring idea in sonification artworks, that by externalising some of the 'expression' in the work; by allocating a responsibility to data, there is a shift of sensibility away from the individual artist or musician, creator of the work, and towards the environment being sonified; the artist adopts a different position. This is a trend, which can be noted in much digital art, where artists see themselves as an element in (as opposed to the author of) a process. There is also a strong ecological presence in sound art, manifested through practices such as field recording and sound walking considered as being less dominant or imposing forms than traditional composing and in some cases sonification can be seen as a continuation of this idea.

Andrea Polli for example uses sonification to render public significant but normally imperceptible data. Her intentions are overtly political; she compares sonification to soundscape listening and sound-walking, which she considers as essentially socially engaged activities [18]. For Polli, audification can readily be considered as an extension to soundscape, since it is the simple translation of non-audible vibration into audible vibration. In comparison, mapping-based sonification (more specifically 'geosonification'[2]) potentially poses other problems, since the translation involves higher levels of human intervention and therein a danger of over-simplification; an inevitable subjectivity appears through the choices involved in the mapping process.

[2] Geosonification: the sonification of data from the natural world inspired by the soundscape.

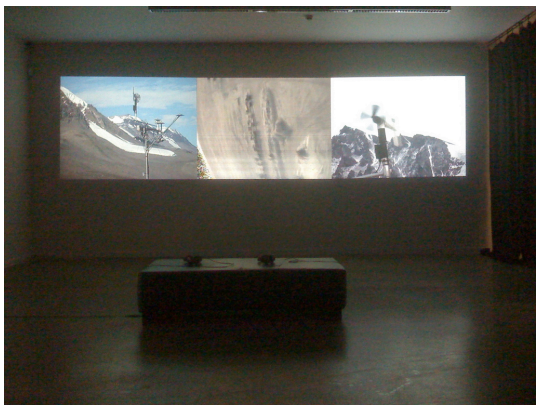

Figure 1. Andrea Polli, *Sonic Antarctica*, 2008

Sound and music are readily associated with cosmology and holistic thinking. The idea that they are representative of the higher (and lower) order of things is sporadically recurrent in Western Philosophy and musicology from Pythagoras onwards. The universality of sound is also largely reflected in non-western philosophical traditions such as Sufism, as this quote from *The Sufi Teaching of Hazrat Inayat Khan* illustrates:

> Since all things are made by the power of sound, of vibration, so every thing is made by a portion thereof, and man can create his world by the same power. Among all aspects of knowledge the knowledge of sound is supreme, for all aspects of knowledge depend upon the knowing of the form, except that of sound, which is beyond all form. (Khan 1996)

That sound and music are appropriate forms to vehicle information that is otherwise imperceptible because too vast to perceive, is a dominant concept in several examples of artistic sonification. Lorella Abenavoli sonifies the vibrations of the earth, compressing them in time in such a way as to render them audible. With her installation *Le souffle de la Terre* Abenavoli invites us to 'drop in and listen to the earth' (Abenavoli 2004) Marty Quinn has worked with NASA using data from solar storms as a source (Quinn 2011), and Richard Kroland-Martinet, Solvi Ystad & Mitsuko Aramaki, sonify cosmic particles —invisible but constantly present in our environment (Aramaki, et al. 2009).
On the other end of the spatial scale Victoria Vesna has collaborated with nano scientist James Gimzewski, creating sonifications of the metamorphosis of a butterfly. Originally stemming from an audification technique used by Gimzewski to display scientific data (the evolution of yeast cells), the Californian artist/scientist couple present this perception of the infinitely small as a public installation entitled *Blue Morph*, which reflects their holistic philosophy:

> As many speculative ideas in the West circulate around ideas of energetic approach to matter in general, particularly the body and mind, alternative medicine and other Eastern philosophies are thriving. …We have investigated these ideas from the sounds of cells to the concept and realization of the Blue Morph installation at the Integratron[3] [23].

Nicolas Reeves, son of the famous French/Canadian astrophysicist and ecologist Hubert Reeves, applies his training in architecture and physics to the domain of media arts. His installation *Cloud Harp* sonifies by reflecting laser beams off cloud cover, using a technology similar to that of a cd player [22]. The artist qualifies his work as 'Keplerian' (in reference to the German Astronomer, who incorporated cosmology into universal mathematics and revisited Pythagoras' *Music Of The Spheres* in his 1619 publication *Harmonices Mundi* [13]). For Reeves, 'Cloud Harp' reflects a social political and ecological position that advocates the integration of human technologies into the greater order of things. The work can be said to 'listen' the environment rather than imposing itself on that environment as such, we can hear an echo of the influence of Murray Schaffer [19].

Another example of sonification, that evokes both scale and in a certain sense politics, is Jens Brand's *Global Player*. Presented as a commercial brand, *Global Player* has a dedicated website [3] that uses spoof advertising to present a genuine technique that consists of sonifying the relief of the earths' surface, from data supplied by orbiting satellites. His advertising slogan is 'Brand – We Play The world– What Are You Playing?' The website offers two products the GP4 'an exclusive, top-notch Hi-Fi product which plays the earth as a disc' and the *G-POD* a portable version of the *Global Player* which looks (suspiciously) like an apple *iPod*.

3.2. Audience Reception

When outside of the domain of pure sound design the perception of sonifications is not necessarily that obvious. If we hear the sound of the earths vibrations compressed in time is it possible to perceive them as such, intuitively, without being informed of their origin by an oral or written explication? If we hear music generated from the pattern of DNA (Gena, DNA Music 1995) is this perceivable in itself? I would say that it probably isn't and in most cases of artistic sonifcation that I have encountered the source of the data is given to the audience through some other means than the sonification itself. The source of the data becomes a signifier or perhaps something akin to the program in program music[4].

[4] Program music appeared in the nineteenth century and consisted of a symphony accompanied by a text that can vary in complexity from a simple title (for example *Tragic Overture* as opposed to *Symphony n°...*) to a text several pages long,

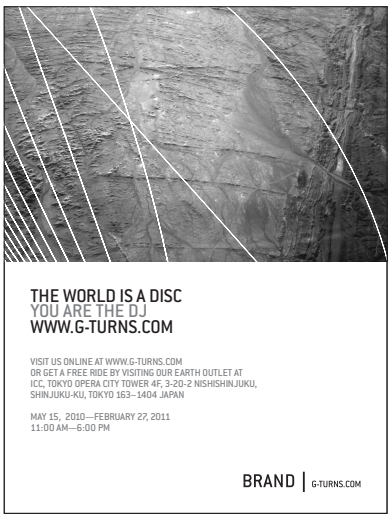

Figure 2. Jens Brand, Brand - finest Global Players since 2004.

If understanding the provenance of the data is integral to appreciation of the artistic proposition, how does the artist make this information available? Alternatively, if the provenance of data is not integral to appreciation, how can we consider that the data is significant? Does attaching a created sound to a source remove it from the realm of 'pure' music?

Take London-based composer John Eacott's work *Floodtide* [6]. I witnessed a performance of this piece in July 2010. The performance took place on a plaza in front of the Southbank Centre in Central London. In the place of music stands, the musicians had flat screen displays showing a 'score' generated by a computer in real-time. The program generating the scores was driven by tide-flow data gathered by a sensor plunged into the Thames below the performing musicians. Strategically positioned posters explained the process with the aid of visuals and a large screen indicated tide flow in knots. The music was agreeable, engaging and minimal in nature. I would place it aesthetically in the school of repetitive music. The performance spanned the six hours of the tidal turn. Although I did not experience the whole duration of the piece I happily spent two hours, half paying attention to the music, half taking in the surroundings. If there is no direct 'comprehension' of the state of the tide through *Flood Tide*, the ensemble –I understand by this the geographical situation plus the generated score plus the human presence of the performers plus the information provided by the posters– 'works' as a whole. The knowledge that the flow of the water next to us was participating in the performance introduced an extra dimension –an extension to the scale of the piece.

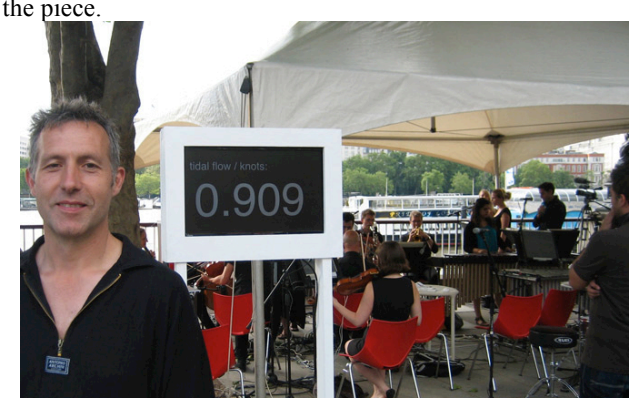

Figure 3. J.Eacott *Floodtide*, London, July 7 2010.

John Eacott considers that data derived from the flow of tide is more meaningful than data generated by stochastic computer processes, but this is not his primary motivation: he willingly talks of his family background in show business and the importance he attaches to spectacle. It would seem that it is this aspect that has pre-eminence over a more esoteric significance that might be suggested by his choice of elements. In the interview we conducted with Eacott he suggested that if today it is necessary to explain to an audience that sonification is taking place, in the future the audience might automatically come to expect that something is being sonified. Perhaps, as John Eacott suggests, some day real time sonification will have become conventional to the point where audiences will be expecting the music to be data-driven. If this becomes the case, it will undoubtedly change the audiences' receptivity to this kind of work but it seems that the data keeps its 'program' status as a signifier, 'what is being sonified tonight? – Ah ok we are listening to …' although it might shift progressively to something which one might guess at without the necessity to consult a poster.

So is artistic sonification necessarily conceptually based? I would venture that when the sonification is intrinsically related to a person's phenomenology then perhaps not.

Christina Kubisch is an international sound artist who has also taken an interest in the invisible and inaudible dimension of electromagnetic waves. Her *Electrical Walks* project is probably among the best known and documented of sonification art works. Publicly presented for the first time in 2003, it predates this in forms that are more experimental[5]. In her description of *Electrical*

pertaining to the composers' intentions (for example Hector Berlioz's *Symphonie Fantastique*). According to Peter Kivy this evolution can be traced to the influence of German philosopher G.W.F. Hegel '…who decreed, at the time the status of music as a fine art was being debated, that absolute music could not be a fine art without a content and could not have a content without a text (Kivy, 2002, p. 192).'

[5] In the Catalogue dedicated to Kubish's works entitled 'Electrical drawings' Christophe Metzger mentions a 1993 experiment where Christina Kubisch and composer Alvin Lucier 'scanned the streets of Tokyo with these modified headphones' [12].

Walks [11] Kubisch explains how, originally unsought after parasites that appeared in her installations[6] became the genesis of this work.

Figure 4. Christina Kubisch, Electrical Walks Nancy June 6 2011 (photo C. Kubisch).

As the quantity intensity and diversity of these parasites increased along with the proliferation of electronic apparatus, she became aware of the artistic potential of visiting this invisible and normally inaudible universe. She constructed special headphones equipped with induction coils, which allow the auditor to hear the electromagnetic waves emitted by different devices:

> Light systems, transformers, anti-theft security devices, surveillance cameras, cell phones, computers, elevators, streetcar cables, antennae, navigation systems, automated teller machines, neon advertising, electric devices, etc. [11]

Members of the visiting public are invited to don these headphones (see Figure 4-3) and discover the hitherto unperceived but ubiquitous and pervasive dimension of electromagnetic waves. This work is a notable exception to the idea that data is necessarily exposed as the conceptual basis of the artwork. I would argue that in this case the artwork is potentially self explicit and autonomous. Christina Kubisch offers maps to her public that indicate spots of particular interest, however, I propose that if one where to wear the headphones without prior knowledge of their usage, one would rapidly comprehend their functionality and ultimately be in a position to appreciate the artistic intention. For this to be the case though, the user must move around and arguably it is this mobility that generates the actual content of the piece.

This idea that if mobilized, a sonification can potentially "make sense" by itself is the basis of my project RoadMusic which I will now describe in more detail.

4. ROADMUSIC

The current version of *RoadMusic* runs on a dedicated mini PC or (since about a month ago) on an adroid telephone in both cases the device is that is fixed to the interior of a car's windscreen (like a GPS) and connects to the car's stereo via a standard audio input. The program uses sensors and a camera.

Figure 5. *RoadMusic* running under *Android* (Photo F. Hartmann).

4.1. How it works

The sensors gather information about movement (accelerometers on x, y, and z axes): vibrations from the car body and the road surface; and on a larger scale bends, bumps, accelerations and braking. The camera gathers information about the visual field: moving objects and colour.

Possibly the single most important (sonic and conceptual) feature of the *RoadMusic* program, is that at the outset there is no pre-recorded audio in the system[7]. It does not use playlists or samples; rather audio synthesis is based upon the incoming raw data –the forms of the road and the cars movements. This data is written into wavetables[8] and read at audio speeds, meaning that the sounds evolve as data updates.

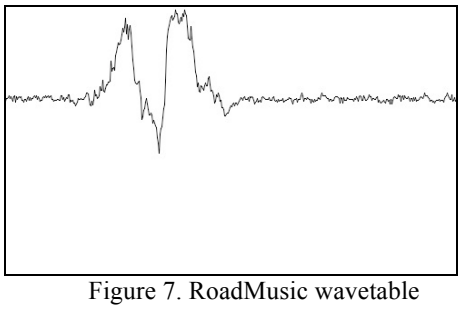

Figure 7. RoadMusic wavetable

This might immediately conjure up the idea something very noisy in the auditory imagination of the reader, however since this is just the starting point of the synthesis (the wavetable is then read by oscillators and

[6] Earlier installations use induction headphones to capture deliberately transmitted sounds as the visitor navigates in a designated space.

[7] There is an exception to this: a recorded voice which gives feedback information about user navigation.

[8] Indexed memory or array of values used in computer music.

numerous other processes are applied to it), it essentially effects the sound on a micro-sonic scale, modifying timbre or texture. The influence of this on the end result is subtle and not necessarily consciously quantifiable to the untrained ear but it eliminates the monotonous nature of many synthesised sounds and importantly *is* the audio 'imprint' of the journey itself.

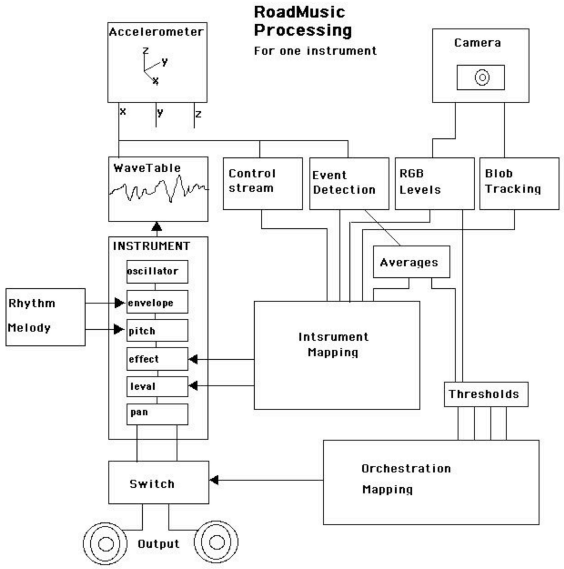

Figure 6. Schema of *RoadMusic* analysis and audio processing

4.1.1. *Instruments Or Streams*

At the next level of complexity up from the wavetables described above, audio synthesis is accomplished by a number of modules generating what will be described later in this thesis as multiple streams[9] –separate audio identities, which for the moment are most easily thought of as instruments. Each of these 'instruments' has basic parameters that can be varied in real-time such as pitch, amplitude and pan and some have more distinctive qualities such as frequency spectrum (tone filter), echo, delay, and 'Doppler'[10] effects that can simulate physical space or movement depending on the instrument.

4.1.2. *Data Analysis And Mapping*

Data from the accelerometers is processed in different ways:

- Each data stream is rescaled and smoothed so that it can be used as a continuous controller by any parameter of any instrument. For example, the varying force of acceleration and deceleration or g-force as the car goes round bends or over bumps, can be mapped to change pitch, level or harmonic spectrum.
- Events are detected within these same streams by measuring difference against time, so it is possible to discern a bump, a bend, an acceleration or a deceleration. These events are used to trigger sounds directly, to introduce or remove notes from melodies, or to switch signal processes on or off.
- These events are also used to calculate statistics about the road –measures of bumpiness, bendiness, stops and starts– that in turn produce new streams of data (moving frame averages). Like the rescaled data, these can be mapped to any parameter of any instrument, causing slower variations that mediate the drive on a macroscopic scale.
- A last level of analysis applies threshold values to the statistical data, producing a new set of events which are typically used to orchestrate the ensemble – switching different instruments on and off according to the type of road, for example: straight, some curves, winding; flat, bumpy, very bumpy.

4.1.3. *The Landscape*

A camera captures the visual field of the road ahead. This capture is analysed in two ways:

- Blob tracking is used to distinguish large moving objects, most often cars in the opposite lane. An object detected in the video frame is translated as coordinates: horizontal and vertical position and size. As with data from accelerometers, these can be mapped to sound parameters. In practice, they are employed to create the impression that a sound is moving correlation with an object outside the car by using psycho-acoustic cues (phase difference, amplitude and Doppler shift).
- Colour of the overall scene is analysed by extracting varying RGB (red, green, blue) component levels, typically used to vary harmonic elements in an instrument. Here too an event is extracted when there is a change in the dominant colour of the landscape and used to bring about changes in the music.

4.1.4. *Global Inactive*

A last but important detection is the non-event: the program provides a signal when no event has occurred for a few seconds, typically when the vehicle marks a

[9] See Chapter 3.3 : *Auditory Scene Analysis*.

[10] Phenomena whereby, when a sound source is moving rapidly towards or away from an auditor (for example a siren or train horn) the perceived pitch is modified.

stop (there is a mechanism which prevents this from recurring more than once per minute to cater for traffic jams and suchlike). This is used to define parameters of a new piece, for example, to re-generate melodic and rhythmical patterns. The compositional process, once the actual code for instruments has been completed, consists of deciding which input parameters are to be routed to which instrument parameters.

RoadMusic's aim is not one of (stricto senso) informing the driver about the road. However there is an intention to create an audio environment (although musical in its form) that puts the driver and passengers in contact with the situation of driving, the road, the car and the environment. Where it might be argued 'normal' listening in a car tends to a large extend to exclude these. Modern (in particular electric or hybrid) cars are isolated from the environment they traverse (even with the windows open at anything beyond minimal speeds turbulence will cover any sounds in the landscape) and car manufacturers do there best to eliminate and mechanical noise. Thus the car HiFi, and has become the by-default audio source, and in most cases unless giving traffic information it is disassociated from the situation. So in a sense RoadMusic applies design principals to a problem solving process. To this end I use the principals of Auditory Scene Analysis described earlier, in order to compose through routines or programs where the absolute result is unknown (the sound of RoadMusic is never the same). By thinking of the Auditory scene in terms of streams with identities and characteristics that separate or approach them it becomes possible to create compositions without knowing where they will start or end and what they will encounter in between. In this I also rejoin with John Cage's experimental music since the composer discovers the piece as it occurs and I would propose that the fact that all the music is generated from audification of the sensor data gives a live quality to the experience (something akin to acoustic sound). Finally I am also aligned to a certain extent with the cosmological camp at least in the sense that one of the aspects of this approach that interests me, is that rather than creating a fixed art work or a performance, the process is one of cybernetic inclusion. By this I mean that the driver the car the program and the environment play together and the limits of such a system are arguably unlimitedly extendable.

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