COMPOSING FOR CARS

Adam Parkinson
Department of Computing
Goldsmiths
University of London
a.parkinson@gold.ac.uk

Atau Tanaka
Department of Computing
Goldsmiths
University of London
a.tanaka@gold.ac.uk

ABSTRACT

The authors report on composing a piece for RoadMusic, an interactive music project which generates and manipulates music for the passengers and driver in a car, using sensor information gathered from the surroundings and from the movements of the car.

We present a literature review which brings together related works in the diverse fields of Automotive UI, musical mappings, generative music and sonification. We then describe our strategies for composing for this novel system, and the unique challenges it presented. We describe how the process of constructing mappings is an essential part of composing a piece of this nature, and we discuss the crucial role of mapping in defining RoadMusic as either a new musical instrument, a sonification system or generative music.

We then consider briefly the extent to which the RoadMusic performance was as we anticipated, and the relative success of our composition strategies, along with suggestions for future adaptations when composing for such an environment.

1. INTRODUCTION

Creating sound environments for automobiles is a complex and rich area of industrial and creative research. Historically, certain cars, notably Italian sports cars, are known for their unique engine and exhaust sound. Aftermarket exhaust pipes are a cottage industry where hobbyists can fine tune the sound of their cars. This was famously picked up by the manufacturer Mazda in the 1980s when they applied Kansei principles (emotional engineering to the sound produced by their MX5 Miata convertible) [10].

Silence is as important as the sound a car produces. While some manufacturers focus on the sound of a car, others focus on silencing exterior noise in the passenger compartment. Manufacturers like BMW use state of the art audio analysis and phase inversion noise cancellation technologies to create quieter environments for driver and passenger alike. A separate problem arises with the advent of the electric car where the car lacks a combustion engine to provide familiar points of reference for those inside, and outside the car.

For the driver, this means that there is no audio feedback from a revving engine to give a sense of acceleration and speed. More dangerously, the lack of external noise means that pedestrians simply do not hear the electric car approaching [12]. This problem has not gone unnoticed by electric car manufacturers, who have embarked ambitious development projects to create external sonification of electric cars.

While car sonification is a task that entails auditory display and sonic design for purposes of feedback (interior) and alerting (exterior), there is an enormous creative opportunity to create interesting, pleasant, yet useful sounds for the car. In effect, Mazdas Kansei engineering could be re-examined completely in the digital domain to produce personalizable, custom automobile audio habitats. Beyond sonic effects, principles of sonification could intersect with interactive music techniques to produce musical environments that are sensitive to a cars state and conditions on the road.

This paper reports on compositional strategies for an existing interactive car music system, RoadMusic, contextualising it within a discussion about the differences between sonification, generative music and the practices of developing new musical instruments [18]. We first describe research challenges, present related work, then describe the technical system. We finish by a discussion of the car as instrument, and strategies for composing for such a system.

2. COMPOSING FOR CARS?

RoadMusic is an interactive car music system developed by the sound artist Peter Sinclair. It deploys Pure Data on a single-board computer having roughly the same size and form factor as a car navigation system or radar-detector. It is attached with a standard suction cup typically used for this kind of automotive accessory to the windshield of the car. A range of sensors provides the computer with real time data generated during a drive. The data is preprocessed by Sinclairs host patch, and passed on to a musical patch that generates music. The computers audio output is connected to the car sound system. The RoadMusic hardware and software in effect replace the car stereo with an interactive music system.

Sinclair sought to create a platform from RoadMusic that could host a variety of different musical works composed for the system. With the idea to create a repertoire of car music, he created a modular software architecture that allows composers to create their own musical Pure Data patches that receive sensor data from the host RoadMusic data processing patch. In completing this composer/repertoire model, Sinclair commissioned a number of composers to compose pieces for the system, and presented them together as a body of work at the 2013 edition of the Reevox festival at the GMEM in Marseilles France.

The present authors were amongst the group of composers commissioned by Sinclair for the premier of RoadMusic. We were provided with a prototype hardware system and the common data-processing host patch given to all the composers. Within this context, we had carte blanche, or complete musical liberty, to create a musical piece that would be presented in a series of 20 minute drives in a fleet of cars during the festival.

This sets the context within which the research reported in this paper is situated. To what extent could we take the commission/composer paradigm as a guide to create a work for the RoadMusic system? What would our compositional strategies be? Would the musical output be generative, sonification-based, or interactive? Is RoadMusic a musical instrument, and if so, is the driver the performer? What areas of research in sound and music computing, such as mapping and interaction, could we apply to this context?

3. RELATED WORK

3.1 Automotive UI

Alongside the industry-led and creative applications mentioned above, Automotive User Interfaces is a growing area of HCI research. The Automotive UI conference began in 2009, and addresses all aspects of user interaction, thinking of the cars as complex interactive systems. [17] We have reported on the RoadMusic system within the context of Automotive UI concerns at the Automotive UI conference [18]. Within this community, there is also research into how much we can infer about a car's environment based upon sensor data gathered from that car: machine learning and data mining techniques have been used to classify road types based upon sensor data gathered from cars [20].

3.2 Sonification

Sonification is in many ways the default approach to making electric cars sonorous. Sonification allows for the transcoding of non-audio data and extra-musical phenomena into sound. An overview of the techniques and research areas of this representative mode of sonificiation, and the related area of auditory dispays, is given by Hunt et al [7].

Ben-Tal and Berger describe uses of sonification to represent data where visualization would be ineffective. By taking advantage of both the temporal nature of sound and human auditory perception capabilities, they suggest that sonification can facilitate pattern detection [2]. Software environments have been created to allow non-musicians to sonify data in this way: SonEnvir is aimed at users from scientific domains, enabling sonification for the presentation and analysis of data [3].

We also see the transformation of data into music in the field of generative music and algorithmic composition. Nick Collins provides an overview of generative and algorithmic musics, contemplating the ontological status of the softwares and creative potentials that might be realised as the composer/ performer's role changes [4].

There is a blurred area between generative composition and sonification. Similar to recent developments in data driven art that diverge from strict scientific visualization, Polansky notes a significant difference between artistic and scientific sonification, the former of which he calls manifestation. Describing how sonification might be used artistically, he suggests that a composer might use the Gaussian distribution not to hear the Gaussian distribution as much as we want to use the Gaussian distribution to allow us to hear new music. [14] Barrass and Vickers contextualise the relationship between the functional role of sonification and aesthetic concerns and the , proposing a design-oriented approach which integrates the two, enabling sonification to be a medium wherin data can be understood and even enjoyed [1]. Doornbusch also considers this artistic or creative end of sonification identifying as a salient example of this Xenakiss Pithoprakta, which used Brownian motion, amongst other phenomena, to score glissandi for strings. Importanly, Doornbusch (and Xenakis) considered this type of sonification as a form of composition [5]. Ben-Tal and Berger describe using sonification creatively in work in which they deliberately avoid representational aspects, with the data imparting a more organic feel to the music, helping to provide rich and varied textures of sound, a technique we came to use in our composition. [2]

3.3 Mapping

The relationship between data input and sound output is described by data mapping. While most literature covers the mapping of performer gesture to sound synthesis , these techniques can be extended to other sources of data, such as we encounter in sonification and related practices.

An overview, taxonomy and analysis of gesture mapping are provided by Hunt and Wanderley [9] Importantly, they note that mapping can actually be said to define the interactive instrument. In this sense mapping takes its place alongside interface hardware and sound synthesis software to comprise the make up of a new musical instrument. [8]

Doornbusch addresses the role of data mapping in algorithmic compositions and generative musics, noting differences with mapping in instrument design. Doornbusch describes how mapping in algorithmic composition is not a discrete process like it is in instrument design, rather it is an integrated part of the composition process and a process of experimentation [5]. However, this might depend upon the specific workflows of composers, performers and instrument designers (who might be one and the same person). Essl has looked at mapping in mobile music, arguing that on-the-fly construction of mapping become part of the creative music making process. [6]

3.4 Interactive car art

Cars have been the topic of interactive art works. Andreyev has explored the cars potential role in a work that draws on Situationist concepts in her project Four Wheel Drift [21]. stergren and Juhlins Sound Pryer used mobile technology and wireless networks to allow car users stuck in traffic to hear snippets of what other users in close proximity to them were listening to. [13]

3.5 Performance environments

Salter takes an environmental view of novel musical performance environments. He takes the notion of performance outside classical frontal stage setups, to think of immersive spaces that are ludic and playful. Roles of listener and player begin to merge, and the definition of the musical instrument extends beyond the sensor system worn by any one participant, to begin to include the smart or responsive space [16].

4. SYSTEM ARCHITECTURE

The RoadMusic hardware consists of sensors (3D accelerometer and webcam) fitted on a fitPC single-board computer, with audio output feeding the cars stereo system. The computer runs a Linux Mint distribution operating system, and Pure Data Extended software with some Pure Data externals, in particular the Gridflow library which is used to process the video input. The Pure Data host framework patch, out of which the composers work, can be broken down into three main components, a Sensor Engine, an Audio Engine and a Mapping Engine [Figure 1].

The accelerometers provide a continuous stream of data representing the acceleration and deceleration of the car, its movement around bends or over bumps, and general changes in the road surface. This data is analyzed to detect prototypical events such as a curve, slowing down or an acceleration of the car. These real-world events are used to send on-off messages to the software or to trigger events in the audio.

The system also keeps a log of the number of recorded events over time periods. This generates a slower stream of data that might describe something more general about a road, a driver or a journey, such as the number of stops and stars, the bumpiness or the bendiness of a road, etc. Sinclairs data cooking extracts further thresholds from these averages, turning them into events according to the characteristic of the drive, so a bendy journey will trigger an event in pure data for the bendiness event. There is also an event trigger sent when no change in input data has been detected over a time period.

In addition to the data from the accelerometers, visual information about the journey is picked up using the webcam which is positioned so that it is looking out of the front windscreen. The first level of this data is the relative RGB (red, green, blue) color balance. The images from the camera are also analyzed and blob tracking techniques are used. The system detects large moving objects, and outputs their relative x, y and z coordinates. The system also performs threshold detection, and outputs an event

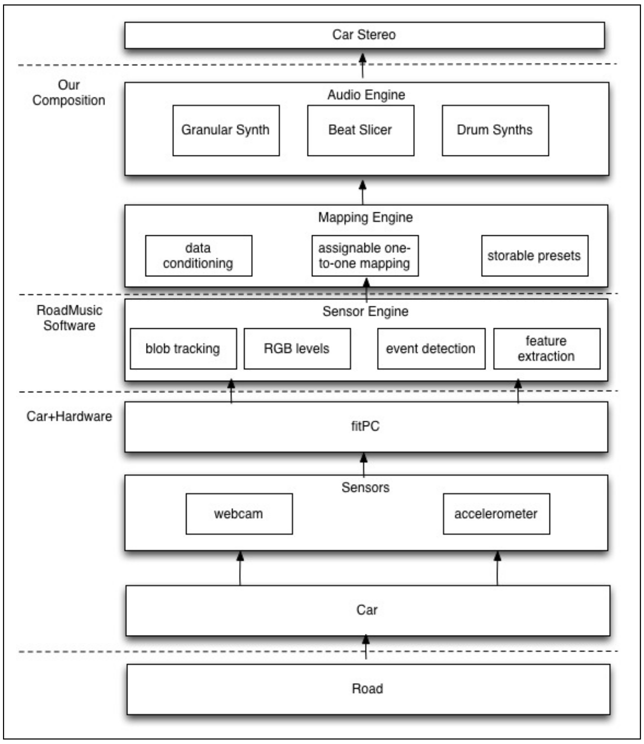

Figure 1. System Architecture.

trigger when there is a large change in the RGB levels, which might be indicative of transition from a built up or enclosed area onto an open road. [18].

We used Sinclairs Sensor Engine, but used our own Mapping Engine to connect this to our own Audio Engine, running on the fitPC, noted by the dotted lines demarcating different system components in Figure 1. At the heart of our Audio Engine is a granular synthesizer, a version of Nobuyasu Sakondas original patch for Max MSP which we have modified and ported to PD and which will play back, loop, and time stretch samples, with pitch and speed both being independently adjustable, and a freeze mode, which captures and repeats small fragments of the sample.

Other parts of the Audio Engine include a beat slicer, developed by one of the co-authors as the tutorial for sample-accurate beat displacement and re-ordering in the commercial MaxMSP distribution. A percussion synthesizer generated analog-like kick, hat and and snare drum sounds.

5. COMPOSITIONAL STRATEGY

Building a mapping environment that was idiomatic to the interactive system in question in turn defined the music composition environment. It is through combining very specific mappings and transformations with certain choices of samples that different sections of our work for the RoadMusic system were created. For this, we needed a Mapping Engine which allowed for quick experimentation with different mappings and transformations, and the ability to quickly save and recall mapping combinations.

In our Mapping Engine, the data is first transformed according to different scalings using objects and abstractions developed by Steiner [19]. These allow for different mapping modes: for instance, inverse relations, or exponential curves, describe the transformation of the input data before it is sent to a parameter. Data can thus only be sensitive in certain input ranges (for instance, only sudden slowing down might affect a parameter). The output range of the data can then be constrained, so that the input data will only affect certain ranges of a parameter. The data can then be smoothed, with different degrees of filtering. This processed data can then be mapped to musical parameters in the patch, with mapping combinations saved (and recalled) as presets.

This permitted us to work in a trial-and-error, improvisatory process of composition with this Mapping Engine. Sinclair had provided all the commissioned composers with example recordings of prototypical drives. These were archived sensor data and webcam video saved as a QuickTime movie, played back in a special simulator module of the RoadMusic host program. Sinclairs simulator combined with our Mapping Engine preset system enabled us to explore different combinations of mapping, transformations, and samples. We found different parameter combinations, and preserved these as presets and messages within the patch.

The composition is a series of these different mapping presets coupled with sample changes. We created a broad timeline for the different sections. In order to achieve a balance of control over the general structure of the piece whilst still having things being controlled by the data, we created systems of arming data, whereby a fixed timeline (score) armed sensors to execute musical section changes in response to specific driving events (eg a bump or a turn) only within specific time windows during the drive. This allowed us to impose a compositional trajectory to the piece, all while leaving the work responsive to events specific to a particular drive, and - we hoped- flexible to adapt to different drivers, cars, and routes.

6. DISCUSSION

6.1 Interaction, Sonification or Generative?

We conceived of three different yet related ways in which one might work with the RoadMusic system, defined by the mappings one would write: it could be treated as a new performance instrument, as a sonification system, or as a generative system. We found these models to be useful referents as we composed with RoadMusic and sought to integrate our own musical practices and compositional intent with the specifics we imagined that the car-as-instrument would demand. [Table 1].

6.1.1 RoadMusic as Performance Instrument

In this instance, the mappings would be used to create clear, immediate gesture-like correlations between the movements of the car and changes in the audio. For instance, accelerating might cause a sound to increase in pitch or amplitude, or a left turn might cause the music to pan to the right. Such correlations would be immediately perceivable to the driver and passengers, and the experience of driving the car with RoadMusic might feel akin to playing a musical instrument, as the drivers actions have an immediate effect on the sound.

This mode of mapping raises an immediate initial concern about safety. We were reluctant to encourage anyone driving the vehicle to make sudden maneuvers for the pure sake of musical satisfaction. This belongs to an area of general concern for those in the field of Automotive UI and a problem specific to the car-as-instrument which affects how we must think about composing for it. Interactive systems in the car must not be distracting, or encouraging of bad driving practice which could infringe upon road safety [11, 15]. In addition to safety concerns, Sinclair has suggested that from his previous work, clearly perceivable mappings can become rapidly incessant and uninteresting [18].

6.1.2 RoadMusic as Sonification

Another way of understanding RoadMusic is as a sonification system, understanding sonification here as the sonic representation of data; this would be the scientific sonification that is referred to by Polansky [14]. Some of this might be immediate, as a bumpy road could affect some synthesis parameter, or some of it might be revealed over time, such as the general bendiness of a journey.

To an extent, this corresponds with certain artistic intentions informing Sinclairs design and use of the RoadMusic system. Sinclair suggests that the system might communicate information to a user in a subliminal manner. This will only happen over time and long term use, as Sinclair notes; through the global recognition of a previous similar sound experience as opposed to the immediate, conscious tracking of a given signal. Furthermore, this may be through somewhat intangible parameters rather than simple, observable mappings and relations, expressed to the driver through the feel of the music as much as anything [18].

In debating how to work with the RoadMusic paradigm, we made a deliberate choice not to opt for any representative, data sonification, Our reasoning behind this was artistically and compositionally informed: we were attempting specifically to make a short (20 minute) piece of music, presumably to be experienced by individual listeners once: not long enough to begin to notice correlations between type of journey, feeling of road, and sound.

6.1.3 RoadMusic as Generative Composition

This category clearly blurs with Polansky's manifestation, or the creative- rather than scientific and representational- use of sonification [14]. While there is a degree of sonification in our RoadMusic composition, our own use of mapping for RoadMusic falls mostly within this category.

The generative nature of our work does not involve any algorithmic processes. Instead, incoming data is used to shape textures and trigger events, to add, as Ben-Tal and Berger [2] do, an organicness to textures that would otherwise be static, but without the intent to explicitly or subconsciously communicate anything to the listener about the car, the road or the journey through such sonic effects. Data is not generated by automatic computer processes, but by the drive itself, and shapes the piece, and may create

	INSTRUMENT	SONIFICATION	GENERATIVE
CORRELATION	correlation between drivers actions and sound perceivable	correlation between car movements and webcam/road data and sound are perceivable	correlation between car movements and sounds may be unclear
EXPRESSION	expressive for driver	expresses data	expresses intent of composer
MAPPING	legibly relates movements to sound	legibly translates data into sound	abstracts data before it affects sound

Table 1. Comparing Instrument, Sonification and Generative Composition.

musical formations that the composer would not otherwise have created, but there is no intentional representative correlation between data and sound. This is achieved through creating layers of abstraction within the mapping.

6.2 Mapping Strategies

We utilized two main techniques in order for the mapping to be a layer of abstraction between the sensor data and the sound produced, blurring many perceivable correlations for the driver/performer and avoiding representative sonification. These techniques were looping data sequences and limiting ranges that the data affected.

Looping data involves using the data to write sequences, which are then repeated and can be sent to any parameter within the Audio Engine. This is based on one of Peter Sinclairs techniques, which involves continuously writing g-force data into tables which are used as the wavetables within the synthesizers and thus affect the timbre and texture of sounds. Sinclair records 13 seconds of data into a 132 sample wavetable. We use an event-trigger from the Sensor Engine to periodically take low-resolution snapshots of these tables, reducing the 132 sample long table to a 16 sample long table. This is then treated as a 16 beat musically loop, continually read through.

Some of this data is used to trigger drum samples: values in certain ranges triggering synthesized kick, snare and hi-hat sounds, transforming into a two bar drum loop, the sequence for which is periodically rewritten. These tables are also used to change musical parameters and loop these changes over two bars. For instance, the pitch of the synthesized kick could be changed over the two bar loop, or another parameter, such as the grain-duration of a granular synthesizer, could be changed. This technique also allows for us to use patterns and repetition within the piece, which will always vary on each different performance of the piece.

Another technique we used to abstract the data in the mapping is choosing the ranges that the data can affect, or in which the data has the most effect. If the data is only affecting a small range of a parameter, it can have the effect of introducing small, continuous variation which may help add richness and a feeling of organicness to a texture, without there being any perceivable correlations between movement of the car and the sound produced for the driver/performer.

7. PRESENTATION AND EVALUATION

Our piece was presented at the Reevox festival of the Groupe de Musique Experimantal de Marseilles (GMEM) on the 9th February 2013. There were 6 cars, each carrying up to 7 people (including the driver) on one of two twenty five minute journeys around Marseille, with a rotating program of 6 pieces written for RoadMusic. This ran from 2pm until 7pm. The different cars, different drivers (with different driving styles), different routes (incorporating small city streets, motorways and tunnels), different audiences (ranging from young children to the elderly) and changing traffic conditions put our composition to the test.

This presentation was our first chance to test our aforementioned compositional strategies with a real audience in a real world setting. Like a composer writing a piece with no orchestra at their disposal and no chance for rehearsals, our first experience of the piece in a car was actually during the first performance itself. Only having being able to test the piece using recordings of data proved to be insufficient preparation for the experience RoadMusic inside a moving car. The experience is highly embodied, and jolts from the road, or the act of g-force upon the body, may be accompanied by a sonic experience. Without being in the car, it is difficult to understand the effectiveness of the mappings or the relationship between the sensor data and the sound.

We had adopted different compositional strategies from the other pieces. These generally involved more tangible correlations between sensor data and music, often with quite noticeable difference being brought about by stopping, by starting the car after pauses at traffic lights, or by bumps in the road surfaces. It felt as though the sensor data was sufficiently abstracted by our Mapping Engine, as intended, but it also became clear that there was perhaps too little correlation between sensor data and sound events in our piece. Anyone hearing the piece multiple times would hear that it was different each time and intimately tied to the data, but anyone hearing the piece only once may find little to distinguish it from a fixed piece of music. Further work on the piece might involve rewriting the mapping to provide some more legibility in correlations between the car's movements or the webcam footage and the sound.

Furthermore, our piece was in a minority that had used a timeline, and the timeline proved to be problematic. Some drives ended up being shortened, meaning that only the first part of our piece was heard by the audience. Also, a rewrite of the piece will be necessary should anyone wish to listen to the piece for anytime longer than 25 minutes. Replacing a strict timeline with a method for organically moving between different sections, would be a more appropriate method of composing, albeit one that might sacrifice some compositional control over structure. We also intend to investigate ways of using the data to provide the structure.

On the whole, the drivers followed the routes as though they were a score in a relatively straightforward way. However, we observed the drivers being expressive with RoadMusic pieces, contrary to our assumptions. They would look for ways of being expressive, perhaps by driving slightly faster at speed bumps or taking corners harder. Correlations between sound, mapping and driving styles are more complex than we anticipated within the context of RoadMusic.

These offer tangible challenges and future work for composing for this unique platform, that lies between being an expressive musical instrument, a system of sonification and a generative composition.

8. CONCLUSION

This paper documented the thoughts behind composing for a novel sound environment, RoadMusic, an interactive music system fitted in car. Mapping is an essential part of the artistic and compositional process. It is an integral part of the programming process (a versatile Mapping Engine has to be programmed), it forms part of an improvisatory compositional process (different mappings are experimented with and successful experiments preserved). It defines the difference between a new musical instrument, sonification and a generative composition, and through the mappings we created a generative composition, based upon our existing Audio Engine. However, there remains work to do be done in understanding the most effective manners of composing for this novel system.

9. BIBLIOGRAPHY

[1] S. Barrass and P. Vickers, "Sonification Design and Aesthetics," in T. Hermann, A. Hunt and J. Neuhoff (eds). *The Sonification Handbook*, Logos Publishing House, 2011.

[2] O. Ben-Tal and J. Berger, "Creative Aspects of Sonification," *In Leonardo Music Journal*, vol. 37, no. 3, pp. 229-233, 2004.

[3] A. Campo, C. Frauenberger and R. Hldrich, "Designing a Generalized Sonification Environment," in *Proc. International Conference on Auditory Display*, Sydney, 2004.

[4] N. Collins, "The Analysis of Generative Music Programs," it In Organised Sound, vol. 13, no. 3, pp. 237-248, 2008.

[5] P. Doornbusch, "A Brief Survey of Mapping in Algorithmic Composition," in it Proc ICMC, Gothenburg, 2002, pp. 205-210.

[6] G. Essl, "SpeedDial: Rapid and On-The-Fly Mapping of Mobile Phone Instruments," in it Proc. NIME, Pittsburgh, 2009, pp. 270-273.

[7] T. Hermann, A. Hunt and J. Neuhoff (eds). *The Sonification Handbook*, Logos Publishing House, 2011.

[8] A. Hunt, M. Wanderley and M. Paradiso, "The Importance of Parameter Mapping in Electronic Instrument Design," in *Proc. NIME*, Singapore, 2002.

[9] A. Hunt and M. Wanderley, "Mapping Performance Parameters to Synthesis Engines," in *Organised Sound*, vol. 7, no. 2, pp. 97-108, 2002.

[10] H. Katayose and S. Inokuchi, "The Kansei Music System," in *Computer Music Journal*, vol. 13, no. 4, pp. 72-77, 1989.

[11] A. Kun, T. Paek, Z. Medenica, N. Memarovi and O. Palinko, "Glancing at Personal Navigation Devices Can Affect Driving: Experimental Results and Design Implications," in *Proc. Automotive UI*, Essen, 2009, pp. 129-136.

[12] P. Nyeste and M. Wogalter, "On Adding Sound to Quiet Vehicles," in *Proc. Human Factors and Ergonomics Society Annual Meeting*, Raleigh, 2008, pp. 1747-1750.

[13] M. Ostergren and O. Juhlin, "Sound Pryer: Truly Mobile Joint Music Listening," in N. Kirisits, F. Behrendt, L. Gaye and A. Tanaka (eds) *Creative Interactions The MobileMusicWorkshop 2004 2008*, University for Applied Arts Vienna, 2008.

[14] L. Polansky, "Manifestation and Sonification," eamusic.dartmouth.edu/ larry/sonification.html, 2002, retrieved 10/02/2013.

[15] A. Rydstrom, C. Grane, and P. Bengtsson, "Driver behaviour during haptic and visual secondary tasks," in *Proc. Automotive UI*, Essen, 2009, pp. 121-127.

[16] C. Salter, M. Baalman and D. Moody-Grigsby, "Between Mapping, Sonification and Composition: Responsive Audio Environments in Live Performance," in R. Kronland-Martinet, S. Ystad and K. Jensen (eds) *Computer Music Modeling and Retrieval: Sense of Sounds*, Springer Verlag Berlin Heidelberg, 2008, pp. 246-262.

[17] A. Schmidt and A. Dey, Preface to *Proc. Automotive UI*, Essen, 2009.

[18] P. Sinclair, A. Tanaka and Y. Hubnet, "RoadMusic: Music For Your Ride From Your Ride," in *Adjunct Proc. Automotive UI*, Salzburg, 2011.

[19] H. Steiner, "Towards a Catalog and Software Library of Mapping Methods" in *Proc. NIME*, 2006, Paris, pp. 106-109.

[20] P. Taylor, S. Anand, N. Griffiths, F. Adamu-Fika, A. Dunoyer, T. Popham, X. Zhou and A. Gelencser, "Road Type Classification through Data Mining," in *Proc. Automotive UI*, Portsmouth, 2012, pp. 233-240.

[21] P. Watson and J. Andreyev, "Four Wheel Drift," in R. Adams, S. Gibson, and S, Mller (eds) *Transdisciplinary Digital Art*, Springer Verlag Berlin, Heidelberg, 2008.