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Topophonie Research Project

Roland Cahen

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Roland Cahen

Topophonie research project

Audiographic cluster navigation (2009-2012)

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The research project took place at a moment when ENSCI as well as most Grandes Ecoles joined the LMD (Licence Master Doctorate) European system for graduate studies. This system includes the development of research projects and PhD theses. In 2006-2007, we already developed another research project on a close topic: ENIGMES (Experimentation de Nouvelles Interfaces pour la Musique Et le Son) about navigable scores or score-instruments (<http://projetenigmes.free.fr>). We identified the subject of Topophonie after the end of ENIGMES. We also decided to associate students with researchers, designers, artists, programmers and industrial partners. All the partners of the project experienced limits with spatialised sound rendering existing methods for real time 3D, such as video-games, virtual reality, in situ sound and artistic installations. We imagined new solutions to these limits and tried to experiment and consolidate them.

Topophonie aimed to carry out applied and not just theoretical research. This meant creating models and forms, which is fundamental for a design school.

The purposes of this publication are:

- summing up and archiving three years of research
- broadcasting our results
- showing an original approach
- disseminating the work of the different participants in the project
- popularising the subject to make it accessible to a large audience
- enabling a larger audience of developers, designers, etc, to have access to more developed material
- showing our students how they can be involved in complex research as true partners
- diffusing the research at ENSCI and advertising for our industrial partners

We have chosen to write this scrapbook in English rather than in French in order to make this research accessible to the international community: our peers and other people interested in the field of art.

Editor: **Roland Cahen**

Artistic director in charge of graphic editing: **Émilie Le Gulvout**

Research supervisor: **Sophie Pène**

Administrative coordinator: **Claire Fernier**



research project
Audiographic cluster navigation (2009-2012)

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Foreword

Fundamental formal research in art & design schools

In the last decade, schools of art and design have started to show an interest in conducting research projects. They were encouraged in this partly because they joined the LMD (License, Master, Doctorat) European system of equivalence. But also because domains and markets of art and design grow more challenging every day, due to the intensity of international competition. In such domains, innovation focuses on content as well as technique. This kind of research necessitates both a scientific rigour and a creative approach for artistic and design purposes.

3 kinds of research

ENSCI - Les Ateliers is involved in at least three different kinds of research:

- **Academic:** analytical and historical research, through the dissertations of students and the research conducted by designers;
- **Creative:** to support artists working on a new project who need to dig deep to come out with a specific result; experiments are made in preparation for an artistic or design project or piece;
- **Research in art & design:** developing new paradigms and methods, more appropriate for collaborative projects including scientists, new technology and its applications, etc.

This last category is also scientific, because its content is Art and it is concerned with creating new domains of practice. Researchers, artists and students can be part of such projects and work together.

Topophonie as new paradigms in digital design

Topophonie explores new ways of producing synchronised sound and images in interactive situations. This exploration is done with the help of scientific work, conception, software engineering and artistic modelling:

- **Scientific work:** developing new systems architecture, standard format improvements and evaluation of user-experience;
- **Conceptual work:** design and audio-graphic modelling to define orientations and expected result;
- **Software engineering:** implementation design and programming;
- **Creation:** creation of models, demonstrators and artistic works.

Designing paradigms and tools for design and creation

Topophonie is a research project in art and design, conceived for the creation of new methods and approaches to designing interactive scenes with sounds and images.

Therefore, Topophonie tries to be a precursor in designing audio-graphic interactive scenes and applications.

Project scrapbook

Topophonie research project

Audiographic cluster navigation (2009-2012)

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Main goals

Topophony literally means *a place of sound, in other words sound spaces, which can be real, virtual or augmented (mixed)*. For example, in real life, sound sources are distributed around us: some are fixed, other are mobile. As listeners, we evolve in a space and constantly mix the sources that surround us. That experience is what we call sound navigation.

When transposing this experience to a virtual world or a video-game, a certain number of questions arise, such as how to represent these sound sources: are they continuous or triggered, punctual or grouped, etc?

In most actual editing tools for interactive sound source distribution, the sound sources are punctual. We are interested in working with other kinds of topophonies.

When audio sources are visible and produce sound at the same time and in the same place as a visual manifestation, we call them audio-graphic.

The aim of the Topophonie research project is **to explore new paradigms and methods of navigation in audio-graphic clusters.**

Who ?

ENSCI - Les Ateliers, the coordinator of the project. Founded in 1982, Les Ateliers-Paris Design Institute (École Nationale Supérieure de Création Industrielle) is the only French national institute exclusively devoted to industrial design. The establishment is under the supervision of the Ministry of Culture and the Ministry of Industry. Today the School covers not only the fields of industrial and product design but also of multiple contemporary design applications: digital, spatial, communication, service design, etc. For over 30 years Les Ateliers has trained designers with highly varied profiles who have gone on to work in design studios, businesses or as freelancers, many of them contributing to France's renown abroad.

L'ENSCI is a founding member of the 'Pôle de Recherche de l'Enseignement Supérieure: Hautes Etudes-Sorbonne-Arts et Métiers' (PRES HESAM) and a partner of the 'Laboratoire d'excellence: Création, Arts et Patrimoines' (LABEX CAP)

Paris Design Lab® is the research lab of ENSCI Les Ateliers

- **Roland Cahen:** electroacoustic music composer, sound designer, researcher and teacher at ENSCI les Ateliers in charge of the sound design studio
- **Sophie Pene:** director of research at ENSCI les Ateliers
- **Claire Fernier:** administrator of research and project assistant at ENSCI les Ateliers
- **François Brument:** digital designer and workshop director graduate of ENSCI les Ateliers
- **Marie-Julie Bourgeois:** digital artist and designer, graduate of the Master 'Creation and Contemporary Technology', PhD student at ENSAD
- **Nicolas Weyrich:** digital artist and designer, graduate of the Master 'Creation and Contemporary Technology' at l'ENSCI
- **Laure Garreau:** digital and graphic designer, graduate of ENSCI - Les Ateliers
- **Claire Lavenir:** interface designer, graduate of ENSCI - Les Ateliers

Ircam, Institut de Recherche et Coordination Acoustique/Musique (Institute for Research and Coordination of Acoustic Music) is an institute in Paris dedicated to the composition of electronic music. Ircam is housed underneath the Pompidou Centre, a very large building devoted to the arts, named after the former French president Georges Pompidou. In 1970 Georges Pompidou asked the composer Pierre Boulez to start an institution for music research. Boulez was in put in charge of

the institute, which opened in 1977. Composers were able to work there, composing music, without having to finish pieces by any particular date. They were given plenty of time to experiment. Many modern composers such as Harrison Birtwistle, Jonathan Harvey and George Benjamin have worked there or were influenced by the music that was being composed there. Today musicians working in Ircam continue to provide many interesting new ideas in electronic music.

- **Diemo Schwarz:** researcher, software engineer at Ircam, member of the IMTR real-time musical interactions team
- **Norbert Schnell:** researcher, software engineer at Ircam, member of the IMTR real-time musical interactions team
- **Victor Zappi:** developer at Ircam, in charge of the Unity IAE interface design and integration team
- **Ianis Lallemand:** intern with the IMTR real-time musical interactions team
- **Aymeric Masurelle:** intern with the IMTR real-time musical interactions team

LIMSI - CNRS, the Computer Sciences Laboratory for Mechanics and Engineering Sciences (LIMSI) is a CNRS laboratory (UPR 3251) associated with UPMC and Paris-Sud Universities.

The laboratory accommodates approximately 120 permanent personnel (researchers, professors and assistant professors, engineers and technicians) and about 60 PhD candidates. It undertakes multidisciplinary research in Mechanical and Chemical Engineering as well as in Sciences and Technologies for Information and Communication.

The research fields cover a wide disciplinary spectrum from thermodynamics to cognition, encompassing fluid mechanics, energetics, acoustics and voice synthesis, spoken language and text processing, vision, virtual reality, etc.

- **Christian Jacquemin:** researcher CNRS LIMSI Dept Human/Computer Communication
- Group Architectures & Models for Interaction (AMI), professor at Univ. Paris-Sud 11
- **Hui Ding:** Hui Ding PhD student at CNRS LIMSI and University Paris-Sud, thesis project on Topophonie: 'Level of detail for granular audio-graphic rendering: representation, implementation, and user-based evaluation'.
- **Jonathan Tanant:** Jon Lab SARL, subcontractor for scene design and audio-graphic LOD programming.

Orbe is a software design and development company specializing in mobile and situated applications: Audio-guides, in situ navigation, virtual geographic interfaces, in situ edition. Orbe is also responsible for artistic and design projects as well as events and installations.

- **Xavier Boissarie:** digital artist, game and software designer, director of Orbe.mobi company
- **Nicolas Dacquay:** game Unity developer, graduate from ENJMIN, trainee at Orbe
- **Alexandra Radulescu:** student at ENSCI les Ateliers, trainee at Orbe
- **Sylvia Fredriksson:** graphic and interface design
- **Jonathan Tanant:** Jon Lab SARL, subcontractor for iPhone application development.

Navidis is a software design and development company specialised in service maps for local communities, public and private local services, etc.

- **Philippe Perennez:** project manager at Navidis
- **Aurélie Caumartin:** administrator at Navidis
- **Thomas Derambure:** cartographer at Navidis
- **Julien Beau:** electroacoustic music composer, soundman in charge of collecting and creating a sound library for auditory maps at Navidis

USER STUDIO is the pioneering Innovation by Service Design agency in France. It is organised around a main goal: helping its clients reach the best User Experience possible through their new products & services. The award-winning studio is active within private & public sector organizations, and conducts research in the fields of data visualization as well as tangible

interfaces. It is an internationally acclaimed member of the Service Design community and one of its strongest advocates in Europe.

- **Matthieu Savary:** Founding partner, User Experience design lead, creative technologist, in charge of Research & Development at USER STUDIO
- **Denis Pellerin:** Founding partner, Art Director, in charge of Design Management at USER STUDIO
- **Florence Massin:** Project manager, graphic & information designer at USER STUDIO

Development:

- **Jean-Philippe Lambert:** Max MSP + OSC workflow for corpus 3d navigation
- **Romain Gora:** Unity developer in charge of Unity 3D modelling
- **Jonathan Tanant:** Jon Lab SARL, software engineer in charge of the Topophonie Common Workflow engineering and development
- **Nicolas Dacquay:** Organic metropolis and other editors

Special thanks to: **Alain Cadix, Serge Bouc, Matthieu Foulet, Veronique Huyghes, Julien Gourbeix, Sylvie Tissot, Bruno Angella, Olivier Schaeffer, Ruth Sefton-Green, Mark Heath, Gabrielle Cahen.**

What ?

In virtual reality and video-games, we know how to make scenes composed of graphic and auditory point-shaped elements (e.g. a spot representing an object). However, there is no tool enabling navigation to make scenes consisting of very great numbers of interactive visual and auditory elements or dispersed elements such as in a crowd, a flow of traffic, foliage or rain.

The research project Topophonie explores paths of enquiry and innovative developments for auditory and visual navigation in spaces composed of multiple and disseminated auditory and visual elements. By working in a scientific multidisciplinary group (digital audio, visualization, sound design) with businesses specialised in the domain of interactive multimedia activities, the project Topophonie conceived and developed methods, models, interfaces and audio-graphic renderings of groups of granular objects that are both animated and spatialised. The project team is composed of researchers specialised in granular sound rendering and in advanced interactive graphic rendering, as well as digital designers and businesses specialised in the relevant fields of application. Students at l'ENSCI have also participated to the research project.

How ?

The Topophonie project produces experimental interfaces to control multimedia scenes and tools for real time rendering on synchronised audio and visual channels.

The objectives are to attempt to define a model of generic data and to create an interface for efficient and detailed definition of large volumes of non-homogenous audio and graphic objects, as well as for the smooth and interactive rendering of moving objects.

In order to do so we experimented in different ways.

First we analysed the existing process in real life (with photography, sound recording, video, descriptions), arts, software applications, video-games and scientific publications.

Then we created empiric models, designed examples, demonstrators and experiments. At the same time the scientific team explored new methods for scene definition (X3D extension), Audio/Graphic Level Of Detail, data distribution, 3D sound textures, sound parameters visualisation, etc.

In order to refer to the same corpus of situations, these developments have been conducted on 6 different models: detailed rainfall, movement through foliage, water flows, moving through and over a crowd of people, urban traffic and granular flows.

Then the project partners, generally grouped in teams, developed their sub-projects.

After seeing the results, we merged some of these works in what we called the Topophonie Common Workflow: a system for creating scenes using the results of our collective work.

Several work groups were created according to sub-projects:

- **Topophonie architecture:** ENSCI, Orbe, LIMSI, Ircam
- **Sound engine:** Ircam, ENSCI,
- **Scene & LOD architecture:** LIMSI, Orbe, ENSCI,
- **Auditory maps:** Navidis, ENSCI,
- **Topophonie Common Workflow:** ENSCI, Orbe, LIMSI, Ircam,
- **Tangible interfaces:** USER STUDIO, Ircam, ENSCI, LIMSI,
- **In situ navigation and edition:** Orbe, ENSCI, Ircam,
- **Model user tests:** Limsi, Ircam, ENSCI,
- **Parametric shapes:** USER STUDIO, Ircam, ENSCI, Orbe,
- **Topophonie Unity library:** ENSCI, Orbe, Limsi, Ircam

Topophonie project started 1 October 2009 and ended 31 December 2012. The five tasks were synchronised with the ENSCI biannual schedule.

The PhD thesis by Hui Ding at Limsi CNRS is attached to the project.

Applications

In addition to their association with the conception and development of models in support of scientific research, the designers have conceived demonstrators, the artists have created works and the industrial partners have developed applications for audio-graphic navigation authoring, interactive cartographic and position-determined mapping navigation as well as interactive virtual and augmented reality and tangible interfaces.

Topophonie Common Workflow

- **Topophonie Unity Lib:** library of objects for authoring topophonies in Unity

ENSCI - Les Ateliers

- **Metrophonie:** interactive model of a city for electric vehicle sound design and ambience simulation

Ircam

- **IAEQU:** granular, segmentation and descriptor-based sound engine for Unity and IOS

Orbe

- **Topophonie Mobile:** sound augmented reality application for navigation in torrents and streams for the park in Belleville
- **PeintSon:** situated data edition application for topophonies
- **Métropole Organique:** creation of an audio-graphic virtual growing city

USER STUDIO

- **Swirls and Topophonics:** application for linking graphic parametric shapes to grain sound descriptors
- **DIRTI:** tangible interface for controlling audio-graphic clusters

Navidis

- **Naviphonie (navidium topophonie):** auditory and graphic map online editor

Articles by students working on the project

Students participated in the research project as part of the research process during four semesters. They were asked to research audio and visual document on various subjects, create models, evaluate the user reactions to their model, then produce a paper and a video or an interactive presentation of their work. They were followed by their teacher Roland Cahen, other researchers, industrial partners of the project, and also received help from engineers and programmers for the technical part of their work.

Here is a brief description of the student work within the project.

- **Semester 1:** analysis of clustered audio-graphic live phenomenon through sound recording, photography and video. Then propose means to render a particular expression of their subject. They choose between 5 subjects: crowd, rain, traffic, foliage and granular flow.
- **Semester 2:** Our partner Navidis is working on soundmaps (i.e. Naviphonie application). Students were asked to explore the usage potentialities and the design of auditory maps in general and to develop a model of a personal soundmap. First, by using programming tools such as Flash or Max/MSP and secondly using Naviphonie.
- **Semester 3:** We started to work on an artistic project called Organic Metropolis (Métropole Organique). The students were asked to imagine audio-graphic organic cities, how they grow and evolve, what they look and sound like. At first they studied the existing works in architecture, science fiction, gardens and arts. Then they were asked to set up a personal project on one element of such a city and to design the visual and the auditory aspects. Then they modelled it in 3D and finally in real time audio-graphic 3D.
- **Semester 4:** some advanced and post graduate students were asked to go further into modelling procedural growth of their organic city and some others build scenarios for auditory map use.

Zoe Aergeter & Philippe Thibaut

Audio-graphic focusing and blurring: how to render audio-graphic focusing using blur?

Fig.A. Blurring foliage to simplify rendering? What does it mean in sound?

Fig.B. Photographic study on 3 levels of detail?

Fig.C. Creating foliage with a set of elements: a single leaf and a single branch: it is all in the geometry.
Video link: final model presentation <http://vimeo.com/15128469>



Fig.A

The project seeks to create a realist feeling of foliage for the viewer with a minimum cost for the computer, using graphic and audio blur.

When the depth of field is relatively small, photo cameras create blur in the foreground and/or in the background of the subject. Graphic blurring is comparable with what the human eye operates when focusing on an object: it selects the elements in the real space according to the relative position of the object towards the subject. Blurring can therefore enhance the feeling of immersion because it involves the subject in the representation of objects in virtual spaces.



Fig.B

Can you imagine how this concept of depth of field could be rendered in sound? When listening to music, for example, if our ear focuses on an instrument, it degrades the perception of other instruments in the same way that photographic blur degrades that which surrounds the subject.

Degradation is therefore an integral part of the mechanism of attention. It simplifies graphic and auditory element rendering and at the same time increases the feeling of immersion. But how do we decide where the point of focus is?

Let us take as an example the situation of movement in foliage:

To answer this question we confront two

rendering hypotheses for different graphic and auditory elements.

Our first model is based on the relative distance between the subject and the object: the nearest object will be the clearer. Approaching the subject from any branch sees the leaves become more precise until collision. We call it 'physiological' approach, in the sense that it refers to the subject's vision, my vision as a visitor.

The second model focuses the image in the direction the subject turns to: determining the focus point around which the rest of the space is blurred.

When browsing through foliage, the viewer always sees what he is looking at in focus. Thus background elements may appear sharper than some foreground ones. The user then interprets the result according to his intention or decision to look here or there. We call this approach 'interpretative', because the model somehow interprets the user's intentions.

The blurring of the sound can be rendered using white noise, which is filtered in order to sound like the wind in this particular foliage.

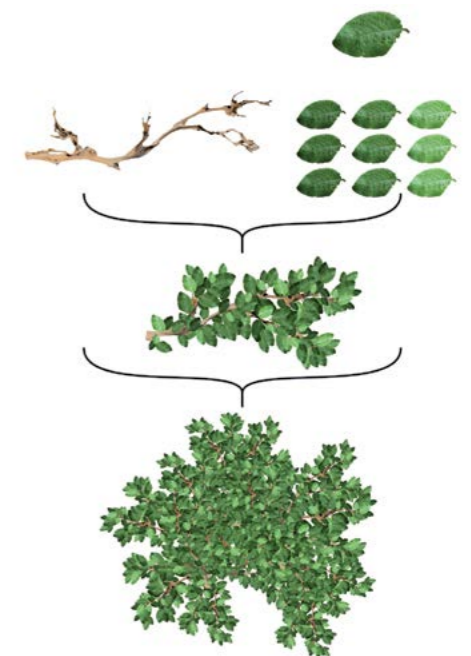


Fig.C

Jonathan Renous

Three representations of granular audio-graphic flows

1. <http://www.flickr.com/photos/topophonie/4995763998/>

2. <http://vimeo.com/52838768>

3. <http://vimeo.com/15020850>

Fig.A. line 1 simplifying the visualization from ink waves to grains / line 2 filming rolling marbles to identify physical and audiovisual interactions, and analyse sound behaviours / line 3 creating an animation with sound to simulate granular interactions at different levels of audio and graphic detail.

Fig.B. Real time 3D interactive model www.topophonie.fr/public_O1 (navigation with mouse and arrows)

Among the selected natural models of the Topophonie Project, I chose to work on a simplified audio-graphic rendering of granular flows.

This work was conducted in three phases of research, to try to understand the nature of the visual and acoustic behaviors of fluids and emit hypotheses about audio and graphic modes of representation, and how they interact with one another.

I first did a photographic study using water and colored ink in a water tube, took pictures of the whirlpool and swirls. Then I reduced the shapes to square dots in order to associate them to sound sources and produce sound interactions. ¹

Secondly, to identify the noise behavior of each of these points, I filmed blue marbles rolling and colliding on a large paper track. The video obtained demonstrated that the sound comes from two phenomena: the collisions of the marbles and the actual rolling. ²

Thirdly, I took the results obtained in the two previous steps to develop a 3D animation. I made a kind of picture of the flow of blood globules in veins: a large number of grains in suspension and I tried to simulate their sound

interactions with different kinds of granular sounds: textures with various granularity, impacts, moving air effects, etc. This 3D animation attempts to identify an auditory/visual point of view/audition that could stick to the behaviour of a fluid at different scales or levels of detail. Visually, the fluids are represented by sequences of points or spheric particles. The sounds are produced by the collision and the friction of the particles with the environment. To these two sound sources, I have added a third one: each particle emits an autonomous continuous sound, without any friction or collision. Finally, I limited the scope of the sound to the camera view, to the inside of the screen. ³

After showing this video to a group of students, I asked them to tell me what the causal mechanisms of the sound production were. To the question 'What produces sound?' they came up with the following results:

2 answered: the rubbing between the particles and the environment

3 answered: the collisions of the particles between them

5 answered: each particle produces a sound by itself

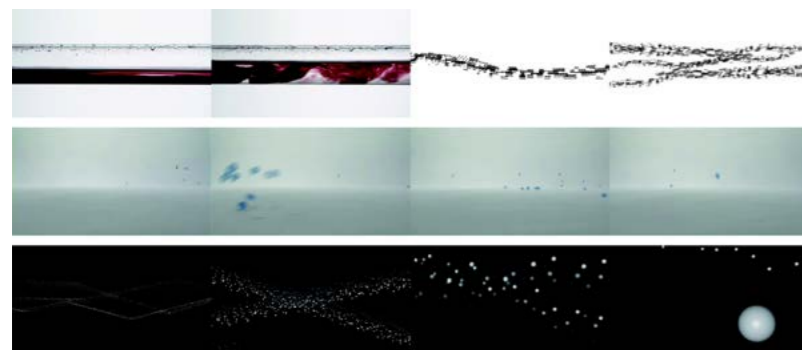


Fig.A



Fig.B

Fig.A. Sketches: Evocations of architecture and plant growth, diversity and randomization. The reconciliation between architecture and nature is not only appearance (organicity, colour) but structure (tree). It can also be built around behavior (birth, growth, evolution, destruction, death). For this project, we put aside visual and audio realism in favour of a more abstract representation. It is the behaviour of the object which evokes plants: the object reacts and evolves with the presence of the user/visitor.

Fig.B. A cell-composed object: diversity with a reduced set of forms. The object is composed of hexagonal cells, which changes gradually. Using cellular object organization, we can obtain complex organic shapes from simple geometrical modules. We started from a regular grid, composed of three hexagons and duplicated them at different scales. The maximum simplification comes to a series of identical objects only differentiated by their positions and sizes.

Fig.C. Program on Unity 3D. The overall logic of the coding of this object is simple: Each hexagon type is recorded in a table with its textures, sounds, etc. Then they are assigned randomly to each chosen group. Groups of hexagons appear in a randomless manner in an area defined by a function and a given time. All parameters are adjustable.

Each hexagon is associated with a sound source. The sound emitted by the hexagon is randomly chosen among a series of chosen samples.

<http://vimeo.com/37893294>
<http://vimeo.com/37891836>
<http://vimeo.com/37891549>

Dorine Lambinet

Organic metropolis, an audio-graphic plant-like architecture

What is organic architecture? How do we build a virtual organic city? How can the visual and the auditive enrich each other in a virtual world experience? How does the user enter in interaction with the space and the object? In Topophonie, we seek to answer these questions through an audio-graphic creation. We have tried to develop a prototype. We got there in three stages: the first working with sound objects and pen on paper, the second with audio and graphic digital edition tools and the third with real-time programming. During the project, we kept seeing the part devoted to form being taken over by programming; but despite the formal constraints, programming also offers a great potential for creativity. The theme of the organic city is also allows open to a wide variety of creative choices, but this freedom is restrained by the necessity of reducing the set of elements to simple blocks (just like buildings in a city). Each object is characterized by its initial state and its evolution. The combination of small elements such as blocks or cells into meaningful form offers unlimited creative possibilities, but what is more difficult is the process by which they are generated.

But this is what nature does. Will we one day be able to even partially reproduce this in a virtual world? Or will we be able to create real implementation of this digital generative vision in the objects that surround us?

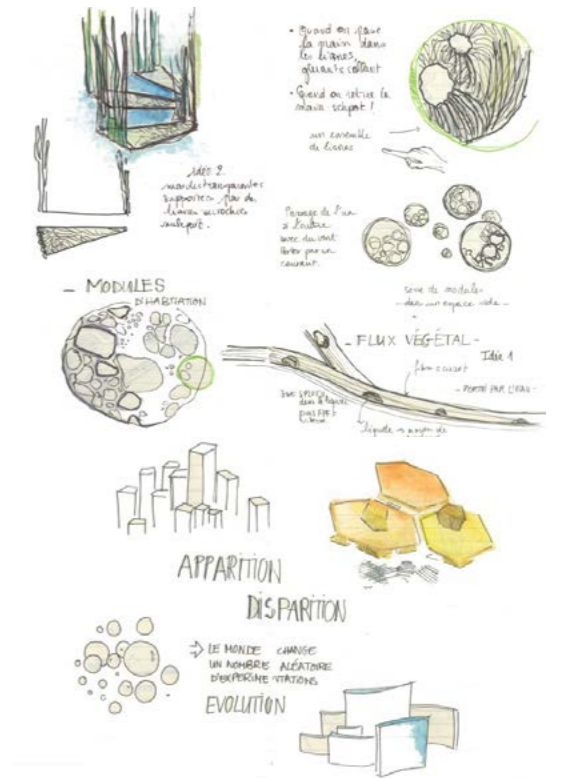


Fig.A

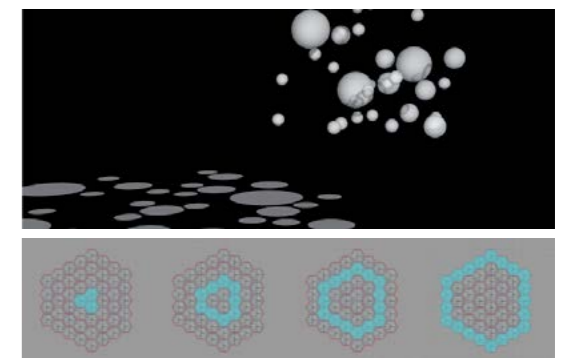


Fig.B

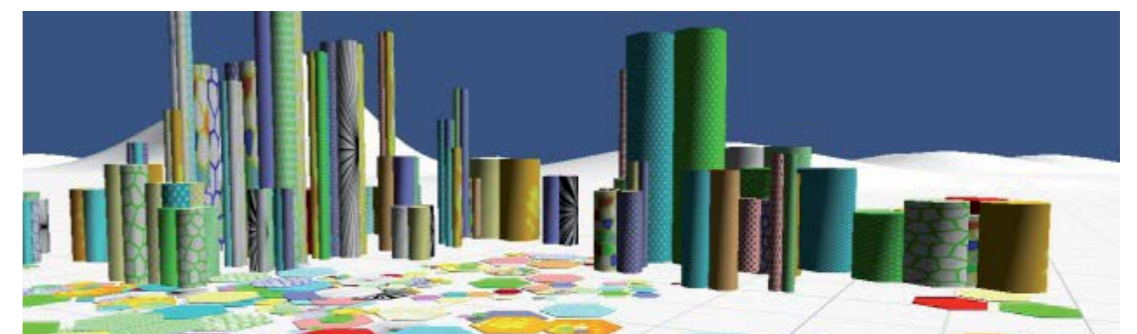


Fig.C

Lea Bardin

Uses and challenges of sound maps

1. <http://www.navidium.com/topophonie/>
2. <http://vimeo.com/21649212>

Fig.A Aerial photography used for a testing auditory-visual maps.

Fig.B. Auditory map representation of Venice.

Fig.C. Auditory map scaling: the most significant scale for auditory maps is situated on the blue segment. Neither too far (no sound), nor too close (not a map anymore).

Lea Bardin questioned the use of soundmaps in general:

New documentary forms redistribute the relationship between digital information and interactions, particularly in the field of interactive maps.

The aim here is to explore how sound can participate in order to enrich these maps. Our work develops experimental models, participates in the design of cartographic editor Naviphonie, its audio interface(s) and features as well as testing the tools and checking the validity of the options selected by user-orientated tests.

Our partner Navidis develops an applicative web platform to allow schools and local communities to create their own informative maps. These maps are not realistic but facilitate the displaying of all kinds of information. Three main patterns for information are the point, the line and the surface. Each item is linked to a caption and can receive colours, images, comments and sounds. The sounds can be ambience sounds, foley, or speech items and can be distributed on points, lines and surfaces like visuals. Different kinds of space and time transitions have been implemented in order to smooth and articulate the different sound layers throughout the sound navigation.¹

Lea first tested several kinds of sound maps.²

One of the tests compared the same sky view of Venice with different sounds mapped on the main routes: 1. a Paris boulevard and 2. a Venetian market. Lea asked which city it was. Most of the people tested answered for 1: Paris or Toulouse, and for 2: Venice because of the sounds they heard.

She did other tests such as asking to choose a restaurant with visual stars and ambience sounds; most testers appeared to be more confident in the sound samples than the number of stars for the choice of their restaurant. Results: Lea organised user tests

on a map in order to understand the difference between visual and audio-graphic maps. She found out that sound was an important determinant for maps.

Her conclusion was that sound was a very important determinant to show activities, which visuals do not show so well. Her work allowed us to use sound maps to represent activities and not static objects or places.

The other result of her work was to show the most effective scale range for sound maps: on the blue segment



Fig.A



Fig.B



Fig.C

Antoine Berr

Looking for an organic city

Intentions: to create an organic audio-graphic world that evolves according to the visitor's movement.

'So here I stand before you preaching organic architecture: declaring organic architecture to be the modern ideal and the teaching so much needed if we are to see the whole of life, and to now serve the whole of life, holding no traditions essential to the great TRADITION. Nor cherishing any preconceived form fixing upon us either past, present or future, but instead exalting the simple laws of common sense or of super-sense if you prefer determining form by way of the nature of materials, etc.' Frank Lloyd Wright, An Organic Architecture, 1939.

Indetermination

Instead of drawing complete shapes, we would rather imagine their growth and reactions based on possible interactions with them: both the morphological evolution of a seed or an object over time and the evolution of the sound environment with the interactions.

How to create using a fractal algorithm, from the development of cells, or work with a environment based on 'clusters' in a 3d space, or a matrix skeleton?

At the beginning of the project, we thought of immersing the spectator in the dark, and have the architecture unveil throughout the navigation. For this purpose we composed a structure of equilateral triangles that are capable of constructing parts and whole cubes. This module can be easily duplicated. These triangles light up according to the viewer's proximity and view axis.

Fig.A. Research Architecture / Sounds: <http://vimeo.com/41835585>

Thereafter we tried to work on the interaction of the visitor with distributed lights and sounds in the architectural components.

We created a zone of influence around the visitor. If two objects within that zone come in contact, then the light intensity and colour change. These same input parameters are also applied to the sound pitch and their radiation.

Fig. B. Research interactions / Light: <http://vimeo.com/41835367>

Very quickly, it turned out that when using the constructions produced beforehand (modelled on rhino) forms were limited to basic and static design. In contrast, working with lights and sound interactions could be a more flexible way of enlivening.

Research environment: <http://vimeo.com/41836170>

Research Spaces / Sounds / Light: <http://vimeo.com/41836587>

CreateBubble / Lights&Sounds: <http://vimeo.com/41834769>

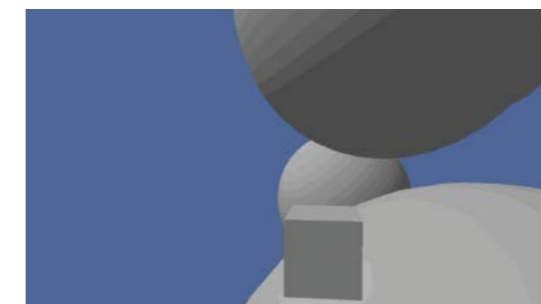
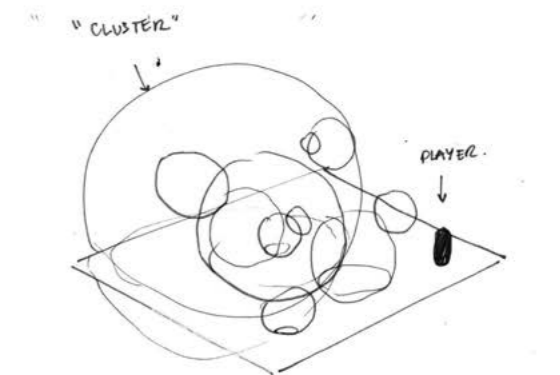
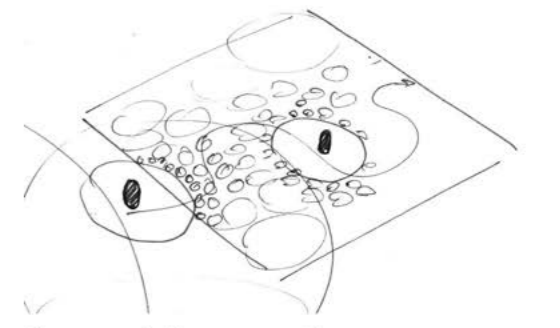
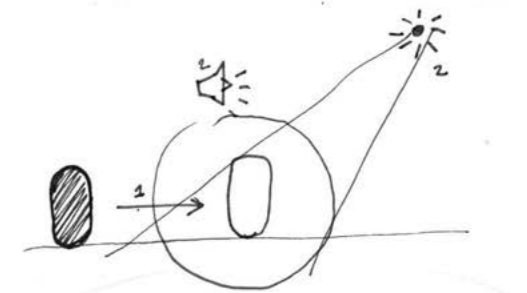
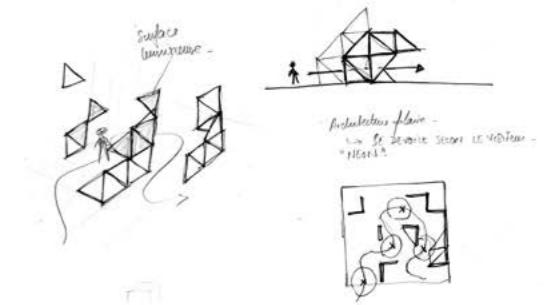


Fig.A

Fig.B

Alexandra Radulescu
Representing organic cities

Fig. A. Scene 2, screenshot; at the start of the programme, two RGBA colour values are randomly chosen. Each time the player presses the space bar, they generate a light source in front of them whose colour is determined by a mix of the first two in random amounts of each. The sound of an object changes pitch depending on the colour value of the light source.

Fig. B. Scene 3, screenshot; the objects in the scene are simple geometric cubes with integrated sound sources; colours and sound pitch are interdependent.

Fig. C. Scene 4, screenshot; this scene is another version of scene 3; differences in the way colour is chosen and in the way it changes over time modifies the soundscape entirely.

Fig. D. Scene 1, screenshot; first scene.

This project proposes a virtual organic environment emerging from the accumulation of simple objects and patterns; their features undergo various changes, resulting in a dynamic image of a living landscape, continuously renewing itself over time.

The first sketch of this space (Fig D) depicts groups of cell-like entities; the result is reminiscent of biological microscopic bodies, but navigation gives the impression of being on a human scale. The aim is to create a path between the micro and the macro and give substance / mass to these objects by way of sound.

The study gradually turned towards abstraction and procedural patterns, looking for a sense of architecture in the articulation and development of geometric audio-graphic elements. The sound they emit measures the stages of transformation and interference they are at and defines their spatial position in relation to the explorer. Thus, we made three other sketches, each representing a different kind of environment. For each scene, the player enters an empty space that they can navigate and model by placing objects in it. A world is consequently



Fig.A



Fig.B



Fig.C

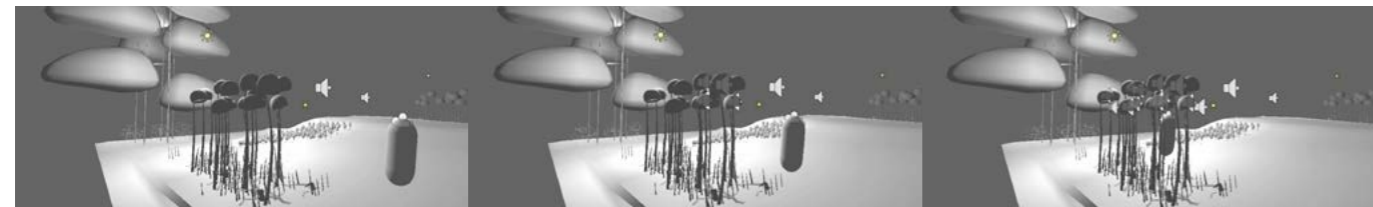


Fig.D

created that they can turn back to and which they can explore.

Following a semester long project at ENSCI Les Ateliers, the research work continued with an internship during the summer of 2012 at the Orbe design studio. The task was to develop

Fig. E. 'brick' element; evolution of the shape in time

Fig. F. growth of city structures, plan view; the horizontal growth rules link the parameters for space repartition, density and buildings' contours

Fig. G. application screenshot; growth of city structures, 3d view

Fig. H. application screenshot; city, street view (1)

Fig. I. application screenshot; city, street view (2)

Fig. J. application screenshot; city, street view (3)

Fig. K. 'brick' modules on a building facade

Fig. L. control of vertical growth; energy flows within building structures

Fig. M. study for vertical growth

graphic models for the Organic Metropolis demonstrator.

The question raised was how to represent a growing urban environment by means of sounding objects that would allow for continuous variation. The study involved the design of individual 'brick' elements, which would develop according to a specific growth scenario in order to finally assemble themselves into structures evoking cityscape imagery.

At the start of the programme, the space configuration map of a new city is decided based on a set of parameters, which define the boundary lines for each building. During a second phase, 'bricks' start appearing and develop vertically from the centre of the previously determined regions. The behaviour of each depends on a genetic algorithm dynamically modelling the evolution process of their shape and the sound that they emit. The presence of the explorer in this world has the effect of temporarily changing the form of each 'brick' at the moment of their passage, thus imprinting the space with new flows and rhythms in terms of shape and sound.

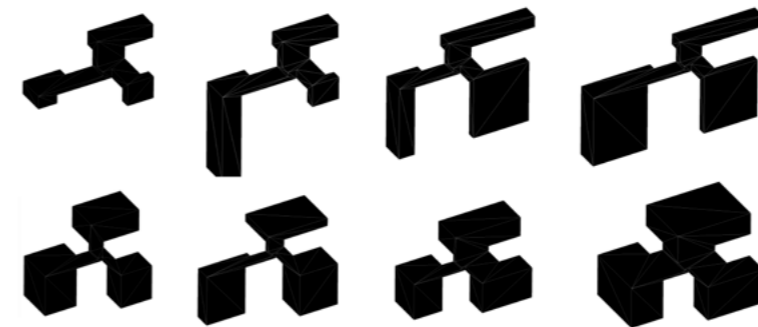


Fig.E

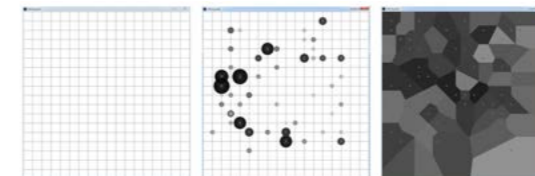


Fig.F

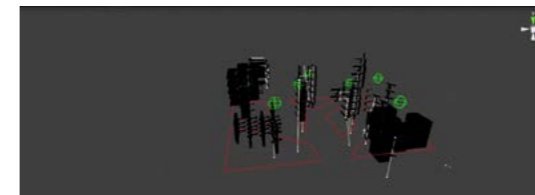


Fig.G



Fig.H

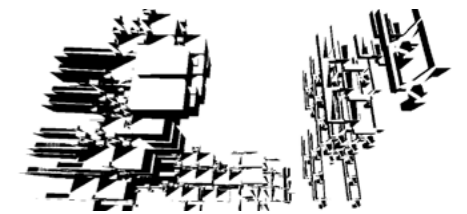


Fig.I



Fig.J

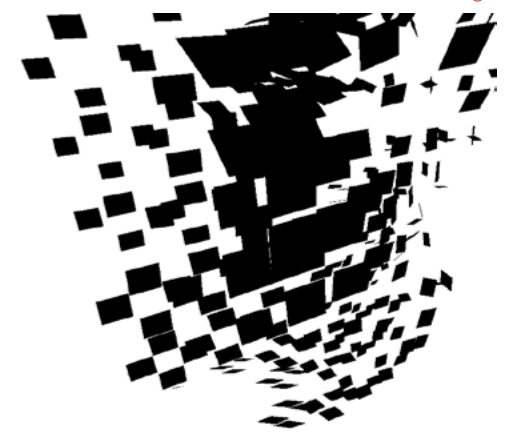


Fig.K

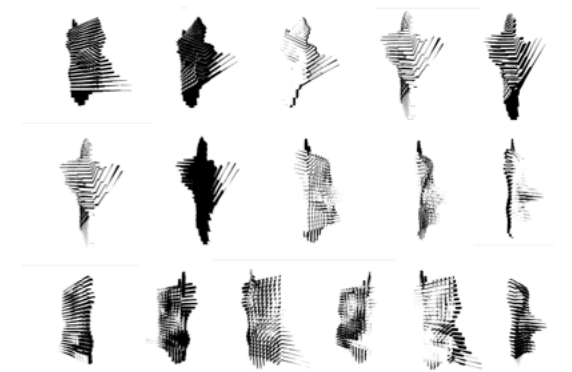


Fig.L

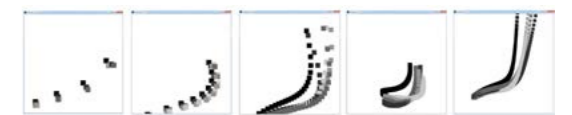


Fig.M

Claire Lavenir

Auditory maps in the classroom

1. For more detail cf. Naviphonie article
2. This choice can appear in the new geography curriculum of seconde (3rd year before Baccalaureat), theme 3 'Development of the city' which is organised around three main issues: the growth and urban sprawl, transport and mobility, and finally development of sustainable cities.

Fig.A. Illustration of the concept

Fig.B. Context of the educational exercise

Fig.C. From left to right: 'Les Halles de Paris' Turgot plans 1739, engraving of 'Les Halles de Baltard' 1940, IGN aerial photograph 'Les Halles de Baltard' 1943.

It is now possible to compose maps in schools digitally and online using a piece of software called Navidium. This software has been designed by the Topophonie project team. It enables us to add sounds to the maps.¹ Auditory maps can be useful to represent activities but also in the context of education as they can help us to give pupils an analytical approach to the sound environment.

The subject of this auditory map is the district of Les Halles in Paris², but the scenario can of course be adapted to any educational context or locality.

The project is to create an educative workshop joining Geography, History, the Visual Arts and Music courses (cf. Fig.B). The pupils would visit the place, make plans and audio recording sounds in situ, collect and edit historical documents, then they could organise these elements on the map in order to express a chosen purpose.

The district of Les Halles has been periodically rebuilt since then beginning of the 20th century, more or less every 30 years (cf. Fig.C). It was the wholesale market in Paris until the late 60s and then became a popular 'Forum with shops,



Fig.A

gardens, a train station and cultural venues...' Now, once again, it is being renovated.

The main idea then is to use sound to confront geographical and historical characteristics of a single place in order to better understand its evolution. The auditory map thus produced illustrates both past and present. These successive historical layers enable a better understanding of the place's complexity as it exists today and to grasp the aims and future mutations to which it may be confronted.

First of all, the pupils carry out a historical research of a given space. The collected sounds

3. The point pictogram corresponds to oral testimony (residents, elected representatives, etc.), the rectangle, square and circular shapes are ambient sounds (square, garden, market, etc.), and finally the dotted line expresses motion such as pedestrian, car, subway lines.

4. The color indicates the period in time the sound samples refer to. The scale ranges between warm colors for the past 1950-1970 to cold colors for actual sounds

Fig.D. Detail of an auditory map of Les Halles.

Fig.E. Possible overlays with various available maps

Fig.F. Geometric pictograms

Fig.G. Interactions with the auditory map: when the cursor passes over a coloured shapen the sound is triggered progressively. Sounds transition are smoothed to facilitate soundscape navigation.

Fig.H. Auditory map with sounds from 1950 to 1970 Market ambience at the time of Baltard pavilions, testimonies of residents about the neighbourhood transformations, cafés, infrastructure works of the RER (regional train), etc.

may come from different materials (extracts from films of the period, documentaries, testimonies, etc.) comprising an auditive library, which can then be consulted when composing the map. The type of captions we would be expecting would be either made of geometric shapes³ or of coloured scales⁴ (c.f. Fig. D and F). The background of a map may vary according to the chosen reading of the given place (c.f. Fig. E). Thanks to these tools, it will become possible to make the first auditory scenery of the district enabling the young listener to relive its past.

After that, the pupils will revisit the site in order to try and see the place in a different light (taking notes and photos, drawing plans and recording sounds. Thanks to new digital tools (smartphones, etc.), pupils can now easily record ambient sounds. These sound recordings, which must always be done in coherence with the task set by the teacher, will enable the creation of varied typologies (interviews, ambient sound...) which can then be reinserted into the audio library.

The map can then be designed with the online software Naviphonie, enabling the pupils to juxtapose the sounds collected in situ, with those from a previous epoch. Thanks to this process, the auditive scenery gains in depth, and we can easily jump from one epoch to another. The superposition of present and past,

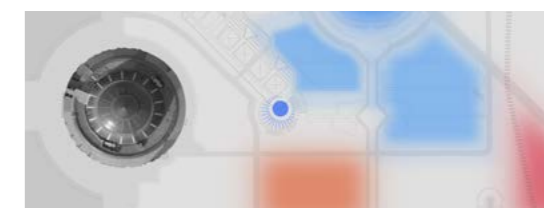


Fig.F

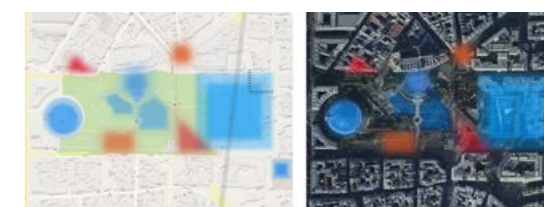


Fig.G



Fig.H

manifest both in the auditory content and the modes of representation in the map, allows varied levels of reading. The auditory map enables us to hear the city transformation.

This educational exercise allows us to experiment with the use of sound at different scales and on different supports. The auditory dimension also offers a renewed form of the more traditional geographical or historical map for both teachers and pupils.

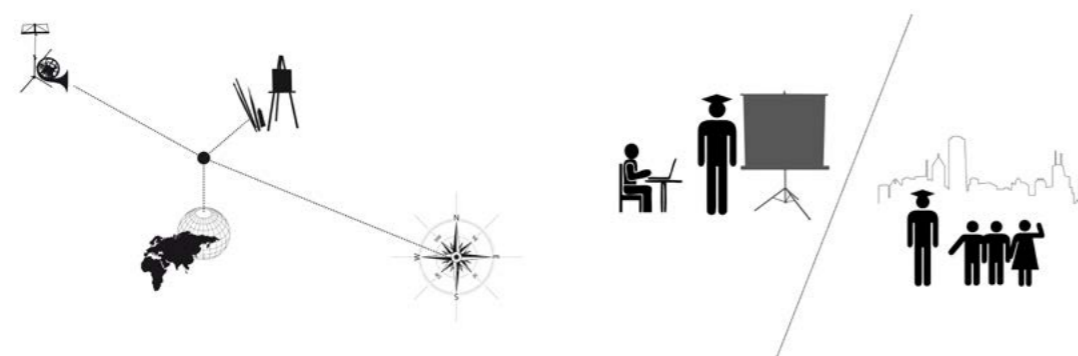


Fig.B



Fig.C

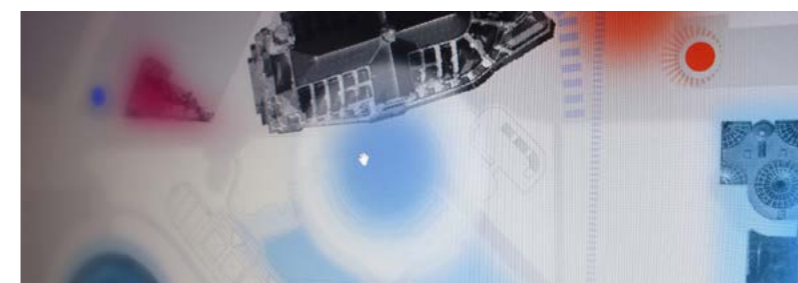


Fig.D



Fig.E

Laure Garreau

Auditory map for 'La Nuit Blanche'^{1,2}

1. <http://www.topophonie.fr/article/12>
2. <http://www.paris.fr/loisirs/les-grands-rendez-vous/nuits-blanches/p6806>
3. <http://www.navidium.com/>
4. <http://www.navidis.com/>

Fig.A. Paris soundmap illustration

Fig.B. Accessing a cultural event programme online, formal drafts around La Nuit Blanche soundmap.

Fig.C. Picture taken from La Nuit Blanche 2008. <http://www.paris.fr/loisirs/les-grands-rendez-vous/nuits-blanches/p6806>

Cities can be experienced in many ways. Their cultural dynamics are a means by which urban environment and its inhabitants are brought into contact. Cultural activities express themselves in various ways, and occasionally occupy the public space. Then art and music come together. Can citizens' socio-cultural experience be enriched by auditory maps? Can we use sound mapped programs of city cultural activities for an easier and better access to arts and urban cultural events?

Naviphonie^{3, 4}, the auditory map application of the Topophonie project, proposes new relational modalities within the city by allowing the creation of auditory informational maps. These maps can highlight noise, ambience and all kinds of localised events. This raises the question of the existence of an urban sound-identity, its possible representation in maps, allowing us to investigate the perspective of the possible uses of auditory maps. As designers, we would like to answer these questions by developing a proper user-experience using auditory maps.

Each year the event 'La Nuit Blanche' gives Paris (and other participating cities) an occasion

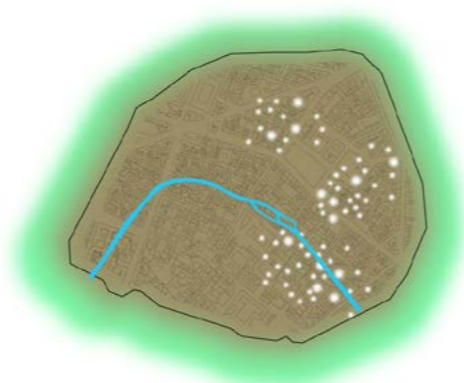


Fig.A

to see and hear different forms of contemporary artistic outdoor creations, associating the works of artists with an urban setting. Many of these events are audio and/or visual spectacles. Using a sound map for 'La Nuit Blanche' allows us to integrate sound as another perspective on the event. We consider auditory maps for cultural events programs to be a way to increase audio and visual information about the event as a complement to or replacement of the literature, but also a good way to spatialise any event's contents. Situated audio clips give voice to the works, the places, the artists, etc., as if the artists or the installation locations could

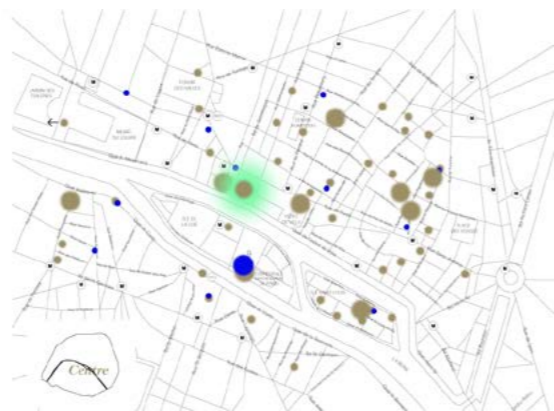


Fig.B



Fig.C

Fig.D. Bercy-Tolbiac district, picture taken at Bibliothèque Nationale de France.

Fig.E. 'La Nuit Blanche' map's background sets up the Bercy-Tolbiac district. Abstract approach.

Fig.F. Soundmap key, icons: artists' interviews, sound extracts of a master piece, ambient sound.

Fig.G.the 'La Nuit Blanche' soundmap final application (online consultation).

Fig.H. Final soundmap.

make possible a dialogue between the public and the event. The 'Nuit Blanche' online sound map could be used at home or on a smartphone, looked at, listened to, consulted for an immersive preview/pre-audition of the night ahead.

The prototyping of interactive sound maps of 'La Nuit Blanche' is part of an iterative process between production usage scenarios, collection for and the structuring of a sound bank (Julien Beau collected the sounds for the application), and formalization via the platform partner project Naviphonie of a series of sound maps. Initially intended for Education, Naviphonie, a self-publishing web 2.0 platform, allows the pooling and sharing of information by the integration of sounds and their parameters in map manufacturing, for different kind of uses.

'La Nuit Blanche' offers an immersive treasure-hunt in a dense and varied programme where sound artists, visual artists, filmmakers and performers inhabit different parts of the capital. The auditory map soundscape is composed of background noises illustrating the urban terrain, artists being interviewed and presenting their work or even recordings of the works themselves!

We experimented with different audio-graphic compositions, then drew and declined various



Fig.F



Fig.G

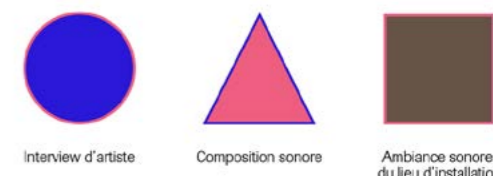


Fig.H

representations from traditional topographic to more abstract means with less geographic information, leaving more place for expressive auditory navigation. These different levels of experimentation query and verify the true measure of audio-graphism, ensuring that sound gets a chance to meet its informative function without being relegated to being a simple complement to visual perception. The sound samples have also allowed us to set the captions of audio-graphic maps in order to identify events as types of sounds.

At the end of this work, two prototypes of 'La Nuit Blanche' sound map emerged and were submitted to a session of user testing. Several insights emerged from this test session: the sound map is widely seen as a singular and pertinent experience. It finally appears that the possibility to listen encourages people to go to the event.

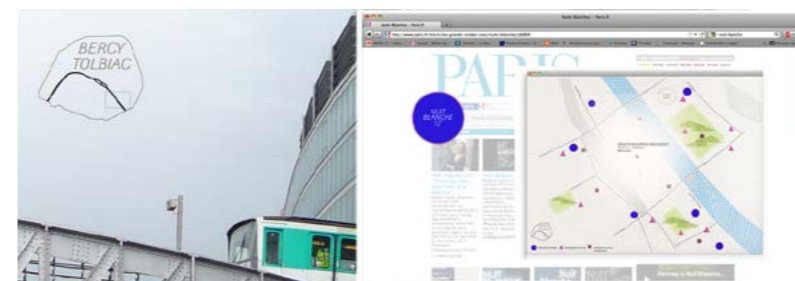


Fig.D

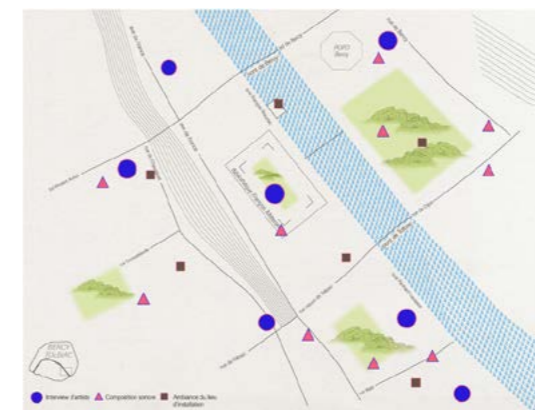


Fig.E

Articles by designer-researchers

Three designers were associated to the project research: **François Brument**, **Marie-Julie Bourgeois** and **Nicolas Weyrich**.

They worked on specific subjects:

- François evaluated the 3D platforms, created a model of rain and worked on the design of the source and listener profiles;
- Marie-Julie designed the Naviphonie interface, worked on the activator profile designs, experimented with various models of foliage simulation, wrote a paper for ISEA and created real-time 3D models for foliage and clustering for Organic Metropolis;
- Nicolas worked on a model of island topophony with a third person and on the Topophonie Common Workflow in Unity design.

François Brument
Modelling rain

Fig. A. Rain particle generation / Obstacles: street, pavement, bus shelters, puddle tree / Impacts of particles triggering the emission of sounds synchronised with splash sprites.

Fig. B. Principle of 'hyper-localised' rain.

<http://vimeo.com/25024929>

Hypothesis 1: 'Hyper-localised' rain
In this model, the production of rain was only made possible in the immediate vicinity of the listener. Just like the cartoons in which the hero is always followed by a cloud of misfortune, we have only modelled the rain for proximity and replaced the background by an impostor (precisely because when it rains you can only see and hear rain if it is close). Indeed, rather than produce a total audio-graphic environment with thousands of drop collisions, a small area around the listener is sufficient to create an audio-graphic expressive rendering. With the process used, the simulation of rain through a cloud of water droplets, the movement is relative to the actor in the scene. At each particle-impact or the collision of a droplet on an obstacle, a single sound and a splash image are triggered. The sound is modulated according to both the nature of the obstacle and the properties of the drop (its size, speed and distance to the listener).
In most particle rendering engines, the properties of the particle-system can change in real time: the scope of the action, the density and intensity of the particles. We could then assess changes in visual and auditory impressions in the functions of these various parameters, and define the thresholds for low and high perceptual quality.
This model is efficient in the evidence of the relationship between visual and auditory perception when elements are close to the

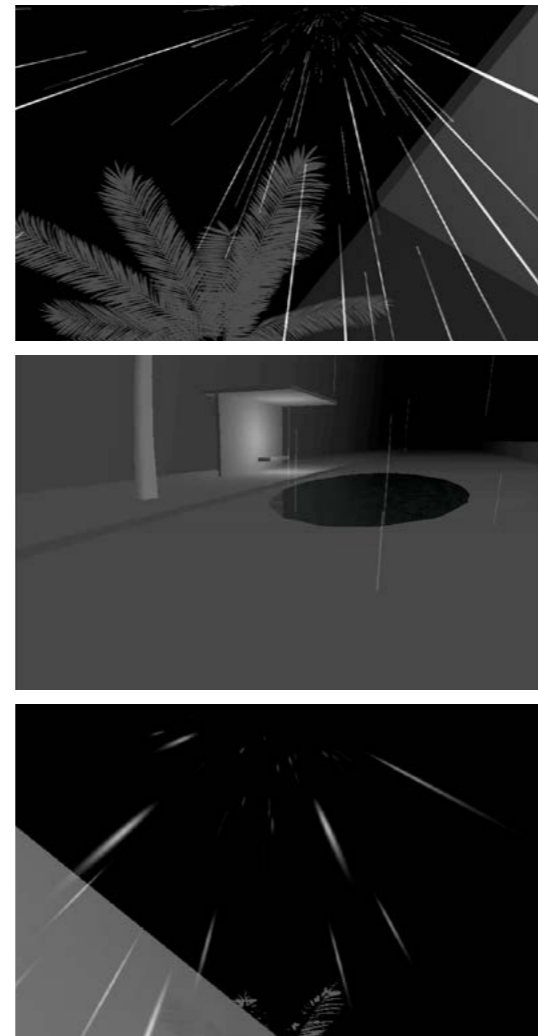


Fig.A

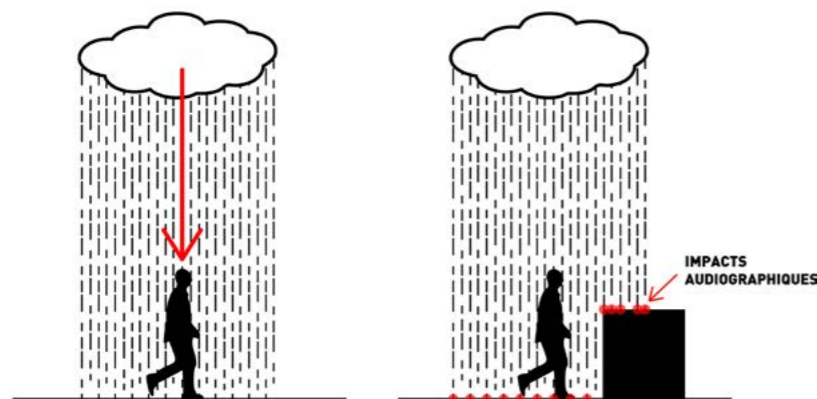


Fig.B

Fig. E. Visualisation of source profiles in a rain scene

Fig. F. Principle of Level Of Detail (LOD): The sound-pattern of rainfall, at different levels of detail is a relevant principle for the production workflow and for auditory perception. However it involves an additional layer in the construction of the 3D scene.

listener, however the model is not sufficient for a satisfactory general perception. In order to favour realism, we chose to complement the model with background fog and white noise.

Hypothesis 2: Managing the rain with several levels of detail
'Hyper-localised' rain models do not allow for the production of the overall auditory perception of an entire scene, so we decided to separate sound renderings of rain on different levels according to the distance they were from the listener. Increasing the scope of 'hyper-localised' rain to the whole scene is not a satisfactory solution, considering the amount of information that we would need to process

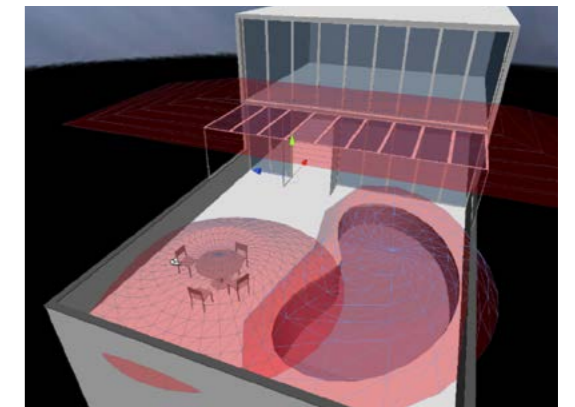


Fig.E

to make the relevant calculations. Three levels of detail are sufficient to create a progressive sound production in order to consume less computational resources. The level of detail is calculated in real-time from the position of the listener.

- Level of detail 1: 'Hyper-localised' rain model; singular physical impact calculations.
- Level of detail 2: Statistical calculation of the number of impacts.
- Level of detail 3: Ambient sound of distant rain.

Hypothesis 3: Sound source profiles
We worked on a way to represent the source-sounds using profiles (source profiles). In order to represent and read the different sound areas and levels of detail in the 3D scenic space, we produced a profile generator that creates 3D forms in the exact place from which the sound is played. Each different sound-source is being covered with a 3D mesh, which gives us a value for the sound changes according to the profile with which the drop collided. At the same time, the shape of the profile provides some information allowing the sound engine to modify the sound according to the thickness of the 3rd dimension of the profile. 3D models of existing objects overlap with envelope profiles.

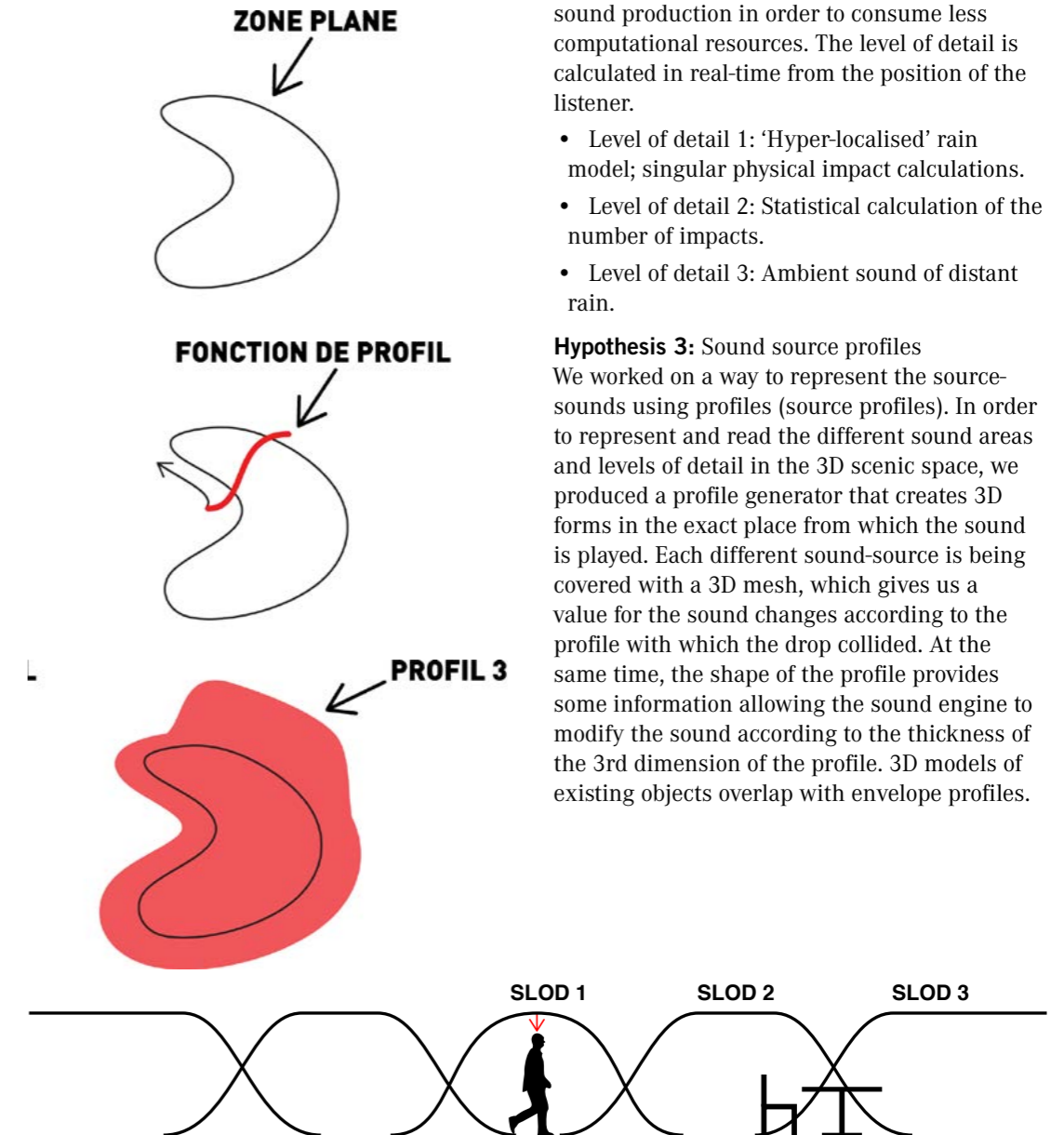


Fig.F

Marie-Julie Bourgeois & Roland Cahen

Crossing foliage

1. Clusters are wide ranges of objects of the same class.

2. By audio-graphic we mean the synchronised audio and graphic behaviour of the object, where both modalities have been implemented in a single action.

3. An activation profile is a simple way of representing active and shaped event triggers.

4. In 'L'audio-vision: Son et image au cinéma' 1991, Nathan-Université, Paris, Michel CHION analyses the perception of an extract of Bergmann's Persona in three stages: sound and image, image, and then sound.

5. Ventriloquism, Mc Gurk effect, works by J. Vroomen and B. de Gelder

Fig.A. Video shots **Human body** crossing various foliage species:

<http://vimeo.com/14823940>

Wind :

<http://vimeo.com/14823976>

Camera :

<http://vimeo.com/14823982>

Fig.B. Pictures of recording at Ircam. Sound sample classified by species:

<http://vimeo.com/14862003>

Manipulation of various foliage species:

<http://vimeo.com/14824022>

User experiments :

The aim of the experiment was to determine the importance of audio-graphic synchronization in interactive manipulations as well as the relevance of activation profile variations. All the tests concern the same scene of foliage: a tree on which leaves can be touched by the cursor which makes them emit a light leaf-noise from our sound library. The test was carried out with headphones. Two kinds of activation profiles were tested: A) the linear profile with a vertical line is a minimal and non-realistic representation of the passage of the wind through the trees, triggering a larger quantity of leaves. But B) the punctual profile with a dot symbolizes the hand of the player.

An analytical and experimental approach to activation profiles for audio-graphic navigation in foliage-clusters

Among the various examples of clusters ¹, such as rain, flocks, grains etc, this paper focuses on foliage. We have selected two main audio and visual behaviours in order to find a good and costless way to simulate both the wind and a person going through the foliage. This paper presents the work of graphic and sound designers. It is an experimental approach, where we have tried to analyse the audio-graphic ² characteristics of foliage through video, 2D and 3D simulation models with popular software. Within the project we developed the concept of activation profile ³. We needed to be sure that this concept was important/noticeable. Therefore, we have compared the user-experience with two different symbolic activation profiles: while a point symbolises the hand of the player, a line symbolizes the wind path in the user-experiment. We concluded with a 3D interactive scene, which simulates the



Fig.A

audio-graphic navigation in clusters of foliage with different types of activation profiles. The videos we made reveal audio-graphic characteristics: vegetable sound is produced by the collisions between leaves, the camera makes a plastic sound and human bodies sound like the rustle of cloth against flesh; as well as showing the graphic behaviour of the different species of plants both during and after the crossing movement. The use of a bodily organ (hand, arm, body, foot) is natural and produces convincing sound when crossing foliage. Certain sound sequences seem fake due to the fact that the sound produced by the body of the cameraman himself is added. Crossing foliage carrying the camera also activates leaves out of the camera field. Therefore the audio and the video images may not be always coherent.

As a consequence, the coherence should be evaluated according to the precision of the physical interaction and the audio-graphic rendering in the field of the camera. Literature about audio-visual synchronization and cross modality perception ⁴ shows that audio and visual are complementary and synchronisation can vary a lot and still be significant. ⁵ However to be effective sound should, one way or another, stick to the visual events that appear in the field of the camera. In addition, this works better when sounds are related to visual events happening within the frame. A non-visualised event, outside the camera's field, often interferes with the understanding of active events. For example, when a colliding object such as the camera or the person, is not visible or definite, its representation is less important. In order to benefit from our own foliage sound library with a variety of different aspects and species we recorded several branches and leaves in the Ircam studio. We manipulated them more or less violently to produce various sound movements and feigned typical effects of crossings: the passing of wind in foliage, of a hand or an object on a leaf, or a group of leaves. Video shots are important to correlate the manipulation of the foliage and the sound produced by the leaves. Actions: by hand, with another branch or leaves: caressing, creasing, tearing away, shaking, crashing and hitting one or several leaves. The remarkable sound differences we noticed are related to the following criteria:

- The inflorescence: the numbers of leaves, their size and shape, the proximity of the leaves, their spatial distribution, the global architecture etc.
- The material: the texture of leaves and how dry they are, and the plasticity of the branch, deformation, elasticity, overlap, bruising etc.



Fig.B

Exp. 1. First we proposed to navigate solely by means of sound on a black screen, and then we asked the users how they found this blind experiment.

A folder (Sound only)

<http://vimeo.com/14824062>

B folder (Sound only)

<http://vimeo.com/14824074>

Interpretation : All testers heard a sound difference between the profiles A and B. Non-specialised listeners often have difficulties to adopt a precise vocabulary without visual reference.

Exp. 2. In the second experience we proposed visual navigation instead of sound in order to separate the perceptual analysis.

Graphic 1 (image only)

<http://vimeo.com/14824087>

Graphic 2 (image only)

<http://vimeo.com/14824095>

Interpretation: The majority of users successfully linked sound and image. We consider that finding the right answer demonstrates the coherence of audio-graphism.

Exp. 3. Finally, we presented the audio-graphic version with the image and the associated sound. We asked users what the audio-graphic version added and what the relevance of using different activation profiles was.

Fig C Linear activation profile:

<http://vimeo.com/14824110>

Punctual activation profile:

<http://vimeo.com/14824104>

Interpretation: According to the answers to this questionnaire, it seems that the audio-graphic version of the interactive profiles give more information about the navigation than either of the sound or image ones. It is also clear that the difference between the two profiles is perceived and understood much more easily in the audio-graphic version than with a single modality. It is therefore a more efficient way of communicating.

Fig.D 3D Interactive scene with a cluster of points as an activation profile

<http://vimeo.com/21154344>

- The energy with which it is manipulated and the kinds of contact between the hand or other leaves: the speed, the movements etc.,

Doing this work, we have noticed that when listening to the sounds without the image of the movement, they all seem to sound more or less the same and it is hard to find a meaningful way to distinguish them. To be able to see them adds very important information for understanding what we hear: spatial origin, causal action, physical reason for a specific auditory particularity, activation mode, action, etc. Applying this method to videos of simple sound-actions such as manipulating foliage appeared to be a very interesting experience, but we realised it was even more challenging to manipulate the simulation in real time. We thought that anyone should be able to tell how convincing or coherent an audio-graphic simulation of foliage navigation is. We then proposed a user-experiment to a small panel of students asking them to manipulate the interactive simulation with sound only, image only and then both sound and image. Using



Fig.C

such profiles allows us to simulate the interpenetrability of clusters or complex objects, for example, the collision of a hand with foliage or a collision between 2 pieces of foliage. In the case of manipulation of foliage, the number of collisions and the sound parameters would be too complex: inflorescence and parameters of materials, multiple triggers etc. Within the Topophonie project, we have developed simplification methods using profiles.

In the following sections we will develop the generic term of profiles: for example, triggers can be punctual or progressive. They can either have the function of source-activator or both source and activator. This paper focuses only on activation profiles. Clusters of triggers are one way to simulate complex profiles. They can have different shapes or size. The sounds triggered by collisions of foliage are multiple. We could use progressive profiles by varying the sizes of units in order to increase and decrease the activation within a profile. The activation



Fig.D

variables can be: volume, density, strength, quantity, speed, agitation, friction, scratching, sounds and visual effects produced by other sources etc. We are now working on more elaborate activation profiles and their audio-graphic behaviours and renderings. The player immerses himself in a 3D environment representing an impracticable jungle. Once the player sees the 'First Person', we can assign a specific form to the activation profile. So we can illustrate the cross of the foliage like a breeze of wind, a hand or a stick... This model demonstrates the necessity of the consistency of the different activations profiles that must match with the collision sounds. In the cluster of points: we obtain distinguishable iterations. The multi-points of contact create more interaction in the game play. We have also noticed that the visual shape of the profile influences the way the user interprets audio-graphic behaviour.

The relevance of using different activation profiles was demonstrated by the user-experiments. In the 3D interactive scenes, we tested various kinds of activation profiles to control different sorts of sound behaviours. The shape of the activation profile and the sound behaviour both determine the meaning and understanding we have of the interaction. The number of units in the clusters and the synchronization of these numerous collisions must be precise enough to express the richness of their interactions. Our experiments and analyses show that the activation profile must be visible in order to visualise the interaction. Players are obviously much better navigators when they can anticipate collisions. This experimental approach provides a new point of view on visual and auditory synchronised modelling. This approach permits us to imagine new forms of audio-graphic expression by navigating across both landscapes and soundscapes. Thus, we can now play with both sounds and graphics, according to the actor's own movements.

Nicolas Weyrich

Topophonie clusters graphic workflow

Fig. A World map, based on data from Ptolemy's 'Geography' (2nd century AD), designed by Sebastian Münster (cartographer in Basel, 1544).



Fig.A

Fig. B Marine microorganisms

Fig. C Euplectella aspergillum, marine sponge



Fig.B

Discretization is based on a simple principle. As it is a complex object, a unit of time or territory is difficult to grasp and manipulate as a whole. 150 BC Ptolemy propose the use of meridians and parallels to divide up space and facilitate its representation in map form. Maps from this era draw on the accounts of travellers who navigated these areas; delimitation made representing territories easier. Once mapped, one can divide up a territory for governance purposes.

Early creators of video games also had to operate in a similar way. In order to generate a rich visual and auditory universe, it is easier for the computer to process basic units (environment, character movement, game space management) and combine them with each other. Super Mario Bros Nintendo Entertainment System fitted on a cartridge with a memory of 40 KB. Today, a PlayStation 3 game fills a 25GB Bluray DVD.

In Topophonie, our aim is to develop software tools that allow us to portray and activate a large number of audio and visual events; in virtual spaces such as video games, or in a concrete navigation experience. This entails optimising resources to generate calculations and a careful organization of data. For example, a city could be designed using a file tree structure, with folders at different levels that contain data: City/districts/streets/building, etc.

Organic Metropolis, a demo artistic project of Topophonie in which I was in charge of graphic design, is a growing organic city of audio-graphic data. We wanted to be able to build not just a few buildings but a whole city. It grows as the visitor travels through it. Every action produces sounds: the construction of buildings,

interactions between these buildings and the visitor, demolitions and various kinds of flows (people, wind, water, etc.) The graphic economy was important to build the whole set. Therefore, we tested various models in order to portray the constituent parts of this city.

I focused on marine microorganisms that evolved into strange and fascinating structures. For example, the Euplectella is a sponge that has been studied by different researchers. Architects use it as a biomimetic construction model. In the field of research about materials, this sponge is related to the secret of making cold glass.

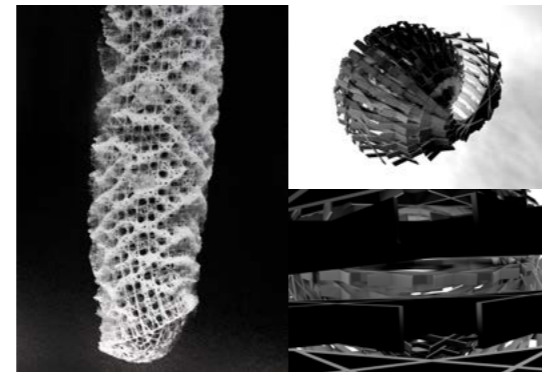


Fig.C

This sponge is like a 3D mesh. Its skeleton weaves a trellis of glass fabric. My data folders could be 3D mesh that grows as Euplectella does. At each node between the links, a cell is created which carries organised information. In a 3D modeller, with the L-system generative process, I designed structures that grow gradually. Over time, the structure emerges. This process is parametric, capable of generating many variations from a single element.

Fig. D. An assembly structure generated by a spiral skeleton



Fig.D

Fig. E. Generations of 3D mesh showing the L-system generative process. The two lines represent two different generations from the base setting.

Fig. F. Study in creating a building: Metropolis Organic

Fig. G Screenshot of a living Island, Topophonie demo

Video ref. <http://vimeo.com/43102106>

<http://vimeo.com/43097264>

The Topophonie software library is a flexible toolkit for amassing large quantities of audio-graphic patterns. (ref. Jonathan Tanant).

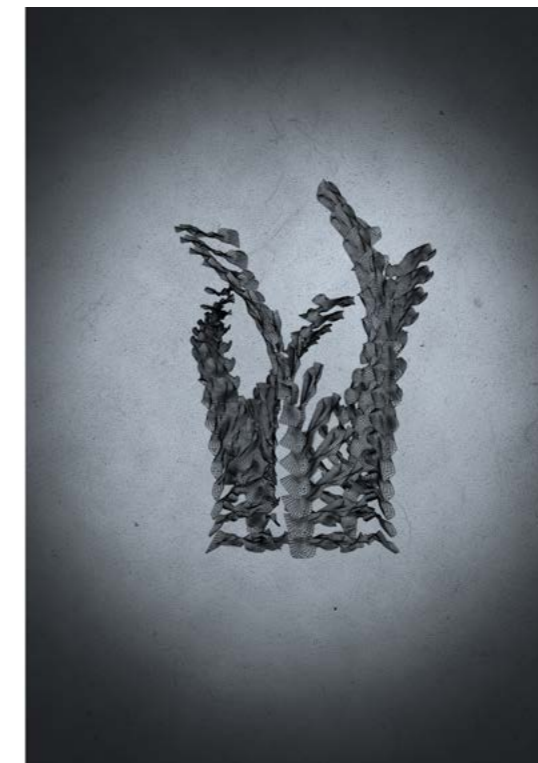


Fig.E

It gives guidelines to non-programmers on how to create large-scale, navigable audio-graphic scenes. As an artist, I was able to experiment with this device to make it capable of generating an interactive format. The creation of this type of device is no longer the reserve of expert programmers; it allows other designers to compose complete scenes with audio and visual interactions, for example, a city scene with vehicles, pedestrians, or a more abstract scene.



Fig.F

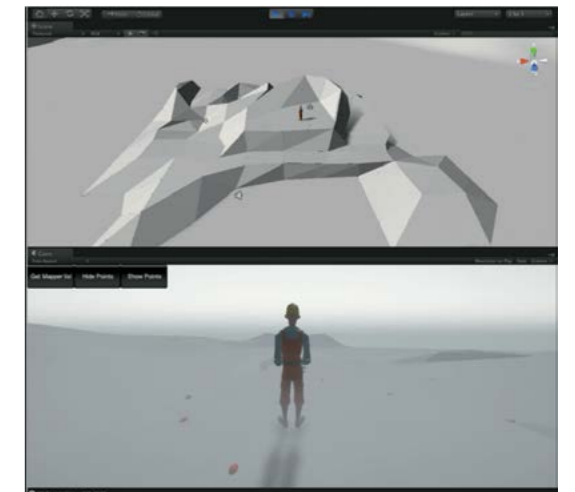


Fig.G

In addition to my work with the Topophonie research team I am working on the design and implementation of interactive video devices. For these projects I often have to use VJing software (Video Jockey) as Modul8 or Arena, which are video players with advanced functions. As the software has evolved it has incorporated greater functionalities for synchronizing with graphical programming software. Video players could be replaced by more advanced generative audio-graphic systems, such as those developed in Topophonie, which turn from the linear logic inherited from cinema towards real-time generative tools, if they become more accessible and stable than they are today. This move has taken place in the sphere of live sound, but could be extended to audio-graphics.

Topophonie research and architecture

The core of the research tries to define and experiment a generic model for audio-graphic topophonies in interactive scenes. It has been developed by all the project partners; the scientific researchers and the companies:

- **ENSCI** worked on the generic architecture model and concepts, as well as defining requests for editors and applications;
- **LIMSI - CNRS** worked on X3D standard format extension, the LOD and user testing;
- **Ircam** worked on the audio principles and methods and the sound engine;
- **Orbe** worked on experimental methods and architecture, development specifications, developed new tools and frameworks;
- **USER STUDIO** developed new concepts and development frameworks;
- **Navidis** studied auditory maps and explored their feasibility on the web.

Roland Cahen

Topophonie architecture and concepts

1. ref. crossing foliage Marie-Julie Bourgeois
2. ref. LIMSI and Ircam develop this particular point in the next pages.

Fig.A. Method for profile design by extrusion and revolution of a simple curve. MJB

Fig.B. Listener profile with 3 Levels Of Detail (LOD). The listener is in the central sphere where the near soundfield is situated (foreground) is very detailed: every sound event is independently rendered. In the middle ground, only a statistical rendering is necessary, such as an ambience or an action associated with groups of events (clusters). The far circle is the background sound. It can be rendered with simple samples impostors.

A topophonie, written here as a common noun, is a literally a space of sounds. Used for scene analysis and design, it designates the geometry of sound distribution and the settings of its expression.

In every day life, we wander in a physical space that contains a large number of fixed and mobile sound sources. As we listen to sound sources, we also interact with them and create sounds ourselves. I call it sound navigation. It is so obvious and so important yet very few people have theorized on this subject. Digital techniques, art and design may make us reconsider the understanding of our everyday auditory experience. Modelling familiar issues of everyday life into the small theatre frame of computers produces alterations that can generate a range of new questions, situations, objects and usages. Observing the real world and modelling some of it for virtual and augmented reality is in itself a challenge. But most fundamental life models can also, if embodied in new creative ways, become roots for growing new expressive paradigms. For example the simple gesture of moving a finger on a surface became a way to surf the whole digital world using a tactile interface.

Therefore, we have developed schemes of subjective experience of scene analysis and methods to model them in computer representations and in-situ augmented reality experience. Topophonie's architecture is mainly a set of experimental methods to articulate sources - activators - listener(s) together.

The sound sources, activators and the listener(s)/triptych

We listeners are surrounded by sounding events that can be modelled as local sound sources. Sounds are activated through our behaviour and the behaviour of other active elements in the scene and their audio properties: we call them activators. In order to create a digital model of this situation, we came out with a model based on three main elements: sound sources, activators and the listener. The question was how to structure the interactions of these three actors.

Each one of these three actors is shaped according to a profile. The profile is the shape of the actor. The activation profile changes the visual as well as the auditory result and the way we perceive it ¹. In order to obtain rich audio-graphic scenes, we create source, activator and listener profiles. The source profile contains the sources' distribution and the sound control parameters associated with them. The activation profile is the shape of the activator. It also carries the sound process; i.e. the settings of one sound event.

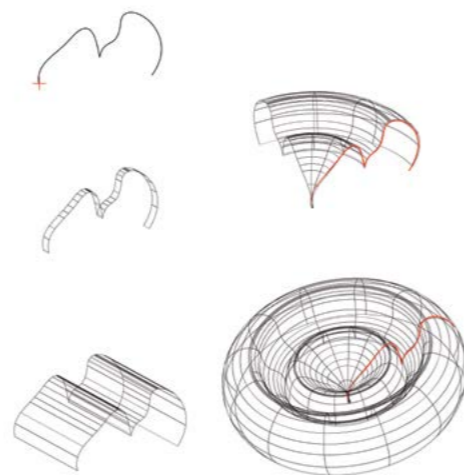


Fig.A

The listener profile expresses the sound according to the Graphic and Sound Level Of Detail (GLOD/SLOD), allowing a simplification of the sound and visual expression and a consequent computing resource economy ².

We also worked on saliency and radiating profiles³.

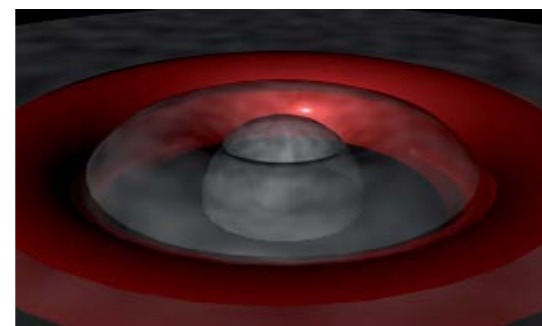


Fig.B

3. i.e. how sounds spread out of source.

4. ref. MJB, FB, HD, Metrophonie

5. SLOD is also called Level Of Audio Detail (LOAD) in other research literature

6. ref Diemo Schwarz next page

Fig.C. Profile of a sound beam security signal for Hybrid Electrical Vehicles in our city simulation 'Metrophonie'

<http://www.topophonie.fr/content/publications/9/file.pdf>

http://www.lasemaineduson.org/IMG/pdf/Metrophonie_Article.pdf

Fig.D. Radiating profiles in Naviphonie auditory map interface. 2D punctual, 2D line, surface (20pix radiation).

Fig.E. Here the wind and the leaves profile is with clusters of spheric activators and sound sources. <http://vimeo.com/37586063>.

By comparison, the Topophonie Common Workflow, implemented in the Topophonie Software Unity Library (ref. Jonathan Tanant) uses a data structure of PointClouds for sources.

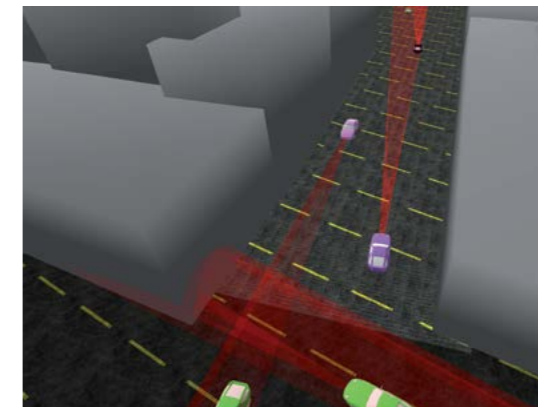


Fig.C

This scheme tries to examine and generalise the point-source approach which is used today e.g. in video-games, in which sound sources and listeners are usually represented by individual points.

Clusters

One important question is how to model the profiles of grouped sound sources and groups of activators. We call them cluster. Unlike single points, groups or clusters have shapes or



Fig.D

profiles, for example a tree is a clusters made of many leaves and branches.

We have chosen a short list of life experimental models of navigable audio-graphic clusters: rain, foliage, a water stream, a crowd, traffic and a granular flow. Then we designed models, implemented various representations of these models and produced real-time audio-graphic navigation demonstrators. ⁴

Virtual vs. situated experience

The same software architecture can apply to virtual and augmented reality. Our architecture can be used for: edition, simulation or virtual reality on a computer as well as in situ navigation or tangible objects.

We have pushed the auditory-visual bimodality as far as we could. The original idea was to create bimodal objects /action for generating both visual and auditory effects. In fact, the software architecture does not always allow this

feature, e.g. sound sources do not always carry the activators. But conversely, a source can express itself both visually and aurally. Thus

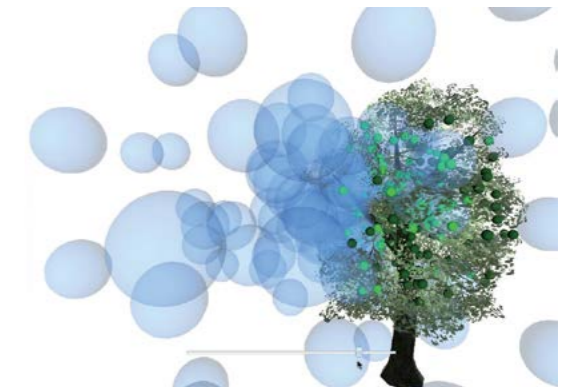


Fig.E

we have adopted the principle of sound and visual synchronicity, in time and in space, as the main property of audio-graphic expression. So any event happening simultaneously and in the same location visually and aurally is audio-graphic. This means that events happening out of the visual field, hidden or too small to be seen, are auditory but not audio-graphic.

GLOD is quite common nowadays, but SLOD⁶ is nearly inexistent ⁵. We have proposed new approaches to this topic and found some ways to implement them.

One difficult issue in the articulation of space and time is the location of actions, especially for moving objects. Sounds are always actions and interactions. When a sound happens in a single place, it may be produced by 2 moving objects, both carrying one potential part of the sound cause; the sound is the effect of their interaction. Therefore, in our model, some parameters distributed in space are not yet sounds, but carry settings for a sound generator. These data will express themselves when an activator encounters them and will be heard only when the interaction occurs in the listener's field.

Sound modelling, texture and sound distribution approach

In order to distribute sounds all over the cluster, we have chosen to work with granular and corpus-based synthesis ⁶. These techniques allow to divide a sound file into many small samples, to trigger and vary them as well as select certain parts of the sound corpus according to the context.

Diemo Schwarz

Audio principles and methods

Fig. A. Modelling of three classes of rain by Gaussian Mixture Models: Sound units and probability density contours projected on the Pitch/Periodicity plane.

In Topophonie, we developed a generic model of data that allows us to define audio-graphic clusters of objects efficiently and precisely, as well as render moving objects smoothly and interactively such that their auditory behaviour is credible, all in a way that requires reduced computational power.

We have chosen to work with the recent technique of **corpus-based concatenative synthesis** (CBCS), which can be seen as a content-based extension of granular synthesis based on audio descriptor analysis. Granular synthesis is rarely used in real-time 3D, because it is more difficult to control than sampling and has higher processing needs, but it allows for the use of recorded sounds, and for real-time control of many parameters such as pitch, duration, smoothness, and timbre in order to produce variation. This method can be applied to produce statistical sound textures and can also replace traditional sampling; moreover, audio descriptors can be used as high-level parameters to control the character of the sound.

Corpus-based concatenative synthesis makes it possible to create sound by selecting segments from a large database of pre-recorded audio (the corpus) by specifying a target position in its timbre space into which each segment has been placed, according to its sonic character in terms of audio descriptors – these are characteristics extracted from the source sounds such as pitch,

loudness, and brilliance, or higher level meta-data attributed to them.

In order to link the evolution of the virtual scene and the interaction which happens within it to flexible sonic behaviour, we devised an audio-graphic scene model based on so-called profiles, linked to any number of presets (possibly in several audio processes) specifying a type of behaviour for each mapping, expressed by the presets' parameters. The behaviours can be either continuous, where the parameters are updated continuously, or triggered, where a sound event is generated in sync with an activity change, e.g. from impacts of raindrops. The advantages of this **4P model** are that it generalises mappings from profiles to 1 parameter (and thus subsumes the direct mapping scenario), to n parameters, or m sound characteristics (when different profiles are mixed).

These profiles can be either proximity profiles, controlling the Sound Level of Detail (SLOD) according to distance from the listener, or they can be activation profiles, controlling a high-level semantic scene parameter of a sound process, e.g. a profile representing a gust of wind can move through a tree in the scene, activating a corresponding synchronised audio and graphical response.

Environmental Sound Texture Synthesis

In Topophonie, we concentrated on the synthesis of environmental sound textures like

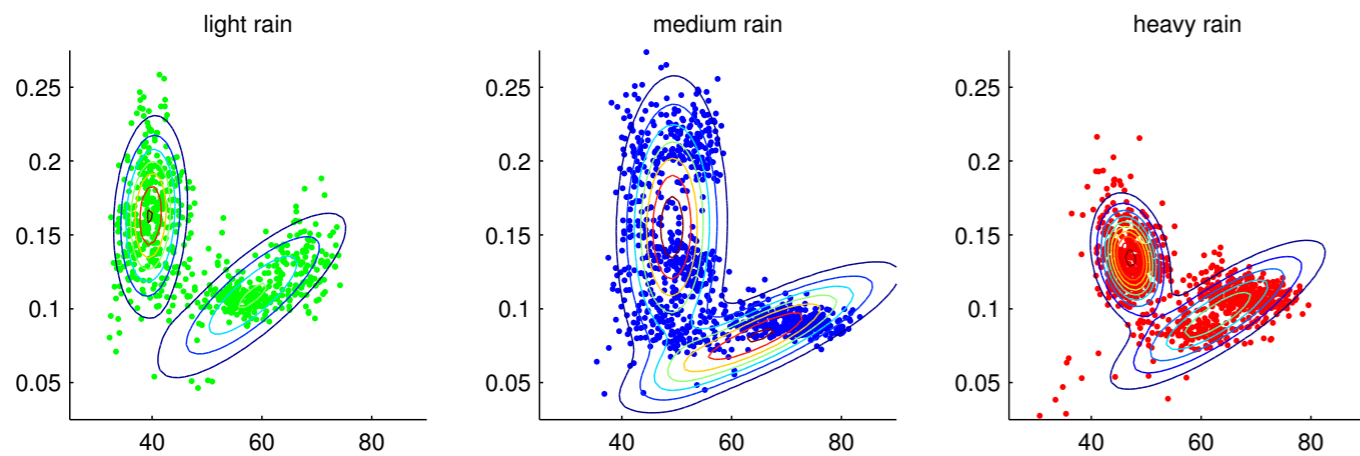


Fig.A

Fig. B. The 4P model: profiles controlling presets mapped to parameters of the sound processes.

Fig.C. Scatter plot of a texture corpus before (left) and after expansion by including the results of sound transformations in the descriptor space (right). The x/y/colour axes are spectral centroid, loudness, periodicity.

these – something which can be applied in film, multimedia creation, games and installations. Sound textures are generally understood as sound that is composed of many micro-events, but whose features are stable on a larger time-scale, such as rain, fire, wind, crowd sounds. The many existing methods for sound texture synthesis are very often concerned with the extension of a given recording to play for an arbitrarily long time, while keeping its overall properties and avoiding anomalies such as looping and audible cut points. However, these methods lack controllability over the sound textures that result from them.

To achieve this, we proposed a method of statistical modelling of the audio descriptors of texture recordings – one that can then be used, varied, or interpolated with other models. In

addition the evolution of the generated sound texture can be guided, either by specifying a target directly in terms of audio descriptors, or deriving these from an existing recording, one that couldn't be used directly (e.g. due to lack of audio quality or a mismatch with the rest of the sound-track).

Our method of sound texture synthesis is firmly based on corpus-based concatenative synthesis, and represents a new contribution to the field. Using content-based descriptors is also vastly superior to using the often scarce or non-existing meta-data.

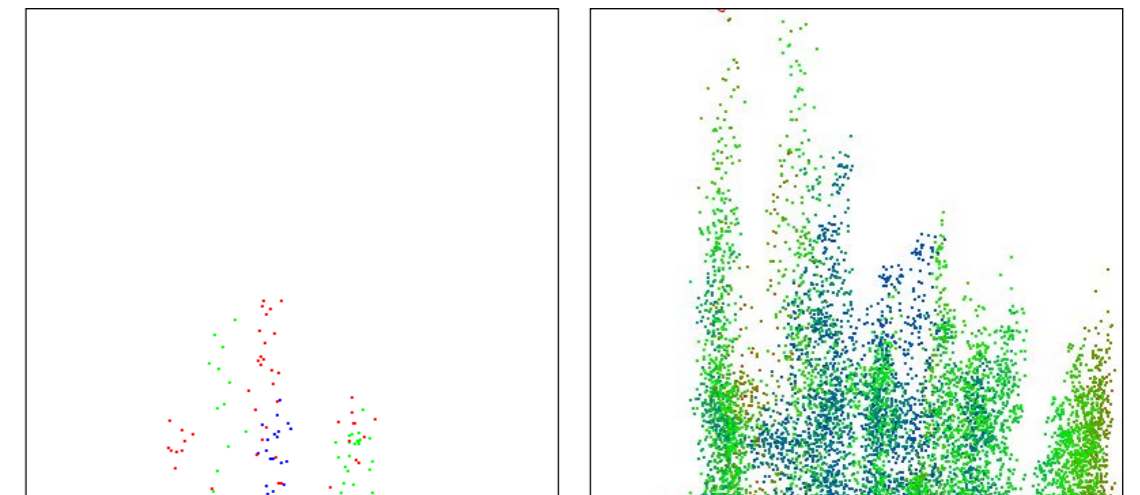
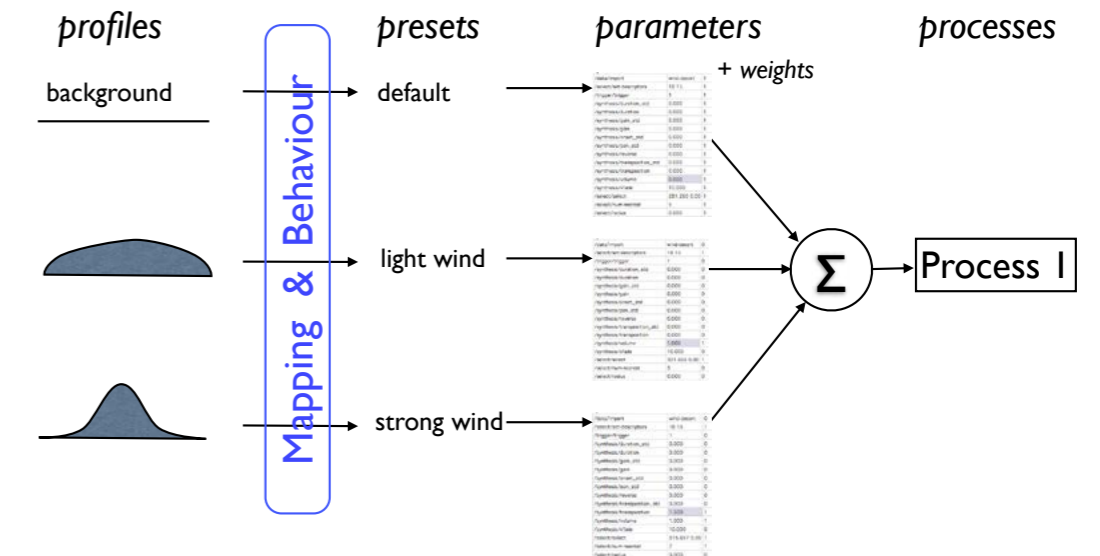


Fig.B

Fig.C

Christian Jacquemin & Hui Ding - LMSI-CNRS & Jonathan Tranant, Jon Lab SARL
Audio-graphic GLOD/SLOD and scene architecture

Fig. A. Three Levels of Detail for the graphical rendering of a tree. The leftmost tree model is the most detailed one and the rightmost, the most coarse one.

One of the core issues of the Topophonie project has been to design, implement, and render granular audio-graphic scenes. The term ‘granular’ means made with a huge number of small graphical and audio elements.

As a consequence, each Topophonie scene contains large numbers of data distributed in space that have to be rendered individually for the sake of precision. For example, a tree is made of thousands of leaves, each of them has a specific shape, color, orientation, and shadowing, and each of them has a specific sound made of the combination of its own resonance and the sound of wind. As for applicative granular scenes, the Topophonie project has focused on various types of common granular scenes such as rain, trees, crowd, urban traffic, etc. We however hope that our results can be extended to any other type of granular scene, with little or no additional developments.

Since the resources of a computer are limited, the full rendering of a granular scene is not possible at a standard frame rate, unless the number of grains remains very limited. For example, a forest, a large crowd, or a rain scene with diverse objects sounding differently

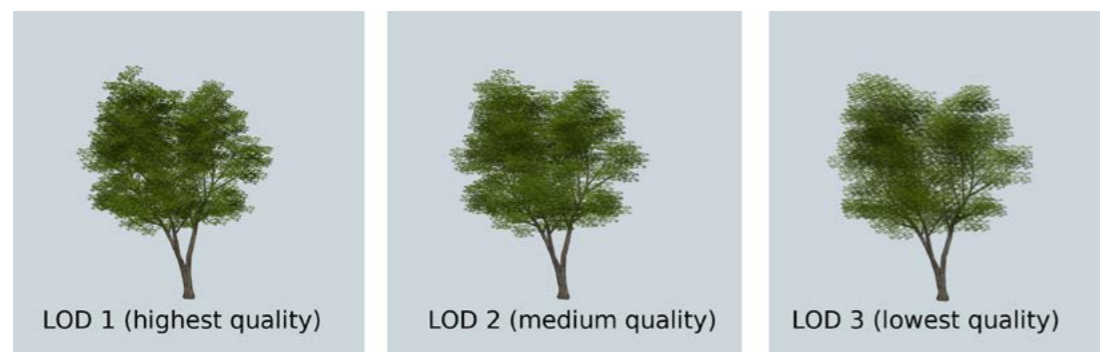


Fig.A

cannot be rendered with all their details. As a consequence, it is necessary to simplify the scene so as to render only a limited number of elements compatible with the available resources.

In graphics, the notion of Level of Detail (LOD) has been used for many years, for the purpose of simplifying a graphical scene in order to

make its rendering possible. The simplification generally takes into account human perception in order to vary the simplifications of objects according to their features (distance, complexity, color, etc.) so that the user would hardly perceived them (cf. Fig. A).

The work of LMSI - CNRS in Topophonie has focused on the notion of audio-graphical LODs by combining graphical and audio LODs in the representation of audio-graphical scenes, the computation of their LODs, and the dynamic control of the LOD selection process rendering:

- The representation of audio-graphical scenes has required to extend to granular audio-graphical scenes the formalisms that were mostly dealing with graphical data.
- The computation of LODs is made either dynamically, or as a pre-computation. Since we are dealing with changing scenes and very high numbers of elements, we have privileged a preprocessing for the creation of audio-graphical LODs..
- Last the selection of the appropriate LOD for each object or collection of objects is made dynamically according to visual or auditive criteria.

All these developments have been carried out in collaboration with the other members of the project. More specifically, LMSI - CNRS has strongly collaborated with Ircam for the audio part of audio-graphic scene formalism and LOD generation, selection, and rendering and with ENSCI for the design of audio-graphical scenes

Fig. B.: Graphical interfaces for user experiments

Fig. C.: Interface used for user-based evaluation. The user can choose among five assessments about the quality of the rendering from unrealistic to very realistic.

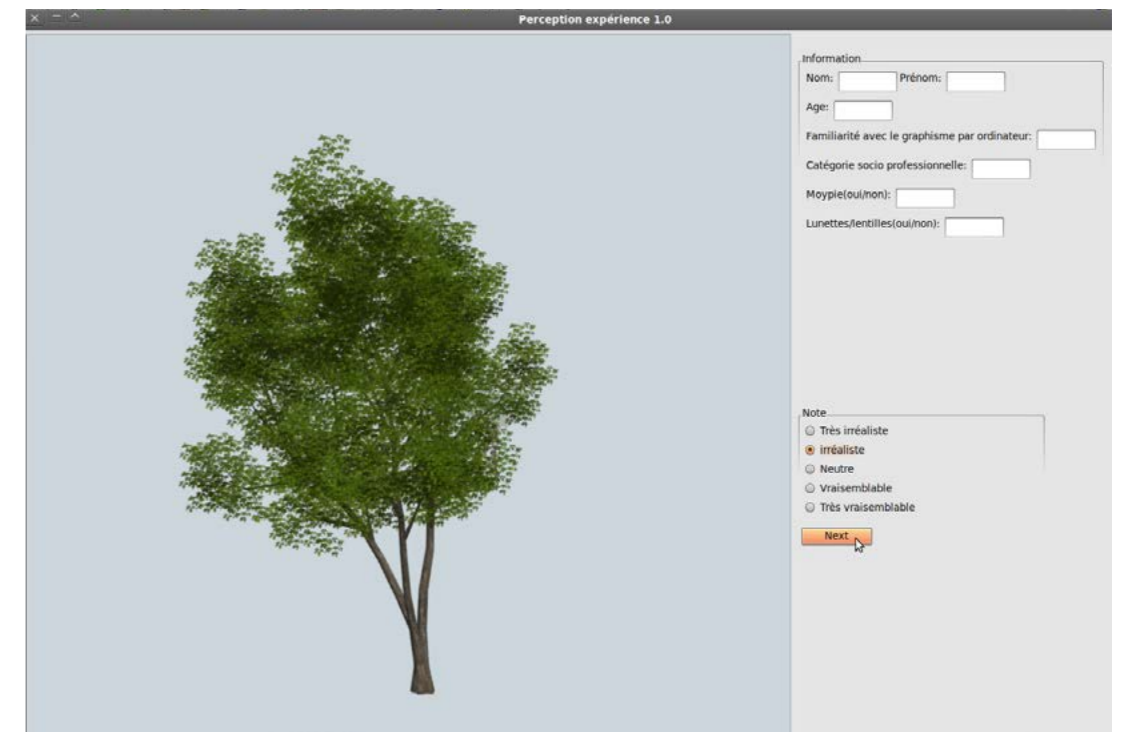


Fig.B



Fig.C

from visual or auditory capture of real-world environments.

Because of the complexity of the scenes, and because of the various parameters to take into consideration, the users are the final judges of the quality of a LOD system. In order to assess and refine the choices made for its LOD rendering, LMSI - CNRS has been involved in several user-based evaluation campaigns (cf. Fig. B). The scene chosen for this evaluation was a tree with a combined audio and graphic rendering (cf. Fig. C).

The evaluation has compared audio only, graphics only, and audio-graphical rendering for calibration purposes. The comparison was also chosen for assessing whether the combination of audio and graphics supports or harms the user's perception of the scene quality at some predefined graphical and audio LODs. The first results did not report any improvement of users' perceptions through the combination of audio and graphics rendering. More evaluation will be made to refine the respective role of audio and graphics in our perception of LODs in virtual granular audio-graphical scenes.

Tools and applications

Within the Topophonie project the partners of the project have developed:

Applications:

- **'Topophonie de l'eau'**, an auditory augmented reality iphone app by Orbe, ENSCI and Ircam;
- **'Naviphonie'**, an auditory map online editor by Navidis and ENSCI;
- **'IAEOU'**, the Unity version of Ircam's IAE sound engine;
- **'DIRTI for ipad'**, a tangible cluster control interface and ipad app by USER STUDIO;
- **'Swirls for CataRT'** by USER STUDIO and Ircam.

Software tools:

- **'Topophonie Unity library'** by ENSCI, LIMSI - CNRS, Ircam and Orbe;
- **'IAE'**, a very powerful and efficient sound engine by Ircam;
- **'CCGL wrappers'** by USER STUDIO;
- **'Dictionary of audio-graphical particles'**, a library of parametric shapes by USER STUDIO.

Demonstrators:

- **'Organic Metropolis'**, an artistic project about a living city (Orbe, ENSCI, Ircam);
- **'Métrophonie'** a city sound simulation prototype with EHV (Electric Hybrid Vehicles) by ENSCI;
- **DIRTI**, DIRty Tangible Interfaces by USER STUDIO.

USERSTUDIO

Matthieu Savary, Denis Pellerin & Florence Massin

Swirls, Topophonics & Dirty Tangible Interfaces (DIRTI)

1. Emergence is the way complex systems and patterns arise out of a multiplicity of relatively simple interactions.
<http://en.wikipedia.org/wiki/Emergence>

2. Corpora: that's just plural for corpus :))
<http://en.wikipedia.org/wiki/Corpus>

Fig.A. Swirls for CataRT
<http://smallab.org/swirls>

Fig.B. Topophonics excerpt: the Atonatiuh particles are an endemic, 12 vertex sub-specie of the Topophonics family.
<http://smallab.org/topophonics>

Fig.C. Topophonics chrono-photography: an Atonatiuh specimen holding a loud & deep audio grain reacts when its movement is fired by the movement of a nearby jellyfish.
<http://smallab.org/topophonics>

Interview: USER STUDIO, what's up with you and these 'audio-graphical' particles?

Particle systems are awesome. We fell in love with them when we realised that there are some things that, no matter how long we would spend trying to design, we would never get them right because they are so complex and their behaviours are so unpredictable... emergent ¹.
Emergent?

Think of trying to simulate tree leaves when autumn sets in: you are fine if you are going to design the behaviours of one or two of them. But when they start multiplying, it is another game. That is what we are into: you do not simulate behaviours and interactions with these things the same way as you would design a single chair. You need to design new tools. We like to do that.

You designed tools?

The first tool we decided to design is called Swirls for CataRT (cf. Fig.A). Our idea, with Diemo Schwarz (Ircam), was to provide a novel way of visualizing the data extracted from the analysis of tiny sound grains (232 milliseconds) that his software (CataRT) is specialised in taking caring of. We designed these parametric shapes that we called 'Swirls' in order to ease the



Fig.A

'readability' of a large corpus of audio grains. Length demonstrates the pitch of the grain, colour demonstrates the brilliance, etc.

Oh I see: data visualisation.

Yes. That is our take at trying to make complexity more accessible to humans. But let us add that in order to represent the complex beauty of the various corpora ² of audio grains, we needed more variety in 3D bricks than just the Swirls, some kind of shapes collection that we would be able to use in order to give life to any kind of sound grains: the topophonics (cf. Fig.B and Fig.C). We are crazy enough to

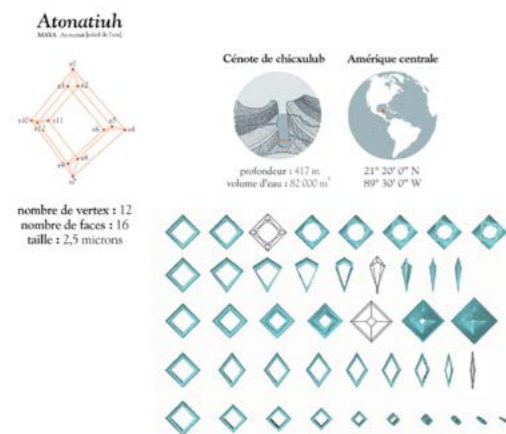


Fig.B



Fig.C



3. <http://smallab.org/download/23>

Fig.D. Dirty Tangible Interfaces (DIRTI) first prototype.
<http://smallab.org/dirti>

Fig.E. DIRTI for iPad prototype used to control a topophonics-based application.
<http://smallab.org/dirti>

have started writing this dictionary of 'audio-graphical' particles, which should be finished by mid to the end of 2013.

Given the tremendous amount of these particles that musicians, composers and sound designers might need to interact with, we then set on a quest to design the tangible interface that would allow them to do just that...

You mean, designing the tools that a musician would use during a concert to control these topophonics?

Indeed. Interacting with a large corpus of sound grains requires more than a mouse-click, more than a few finger taps on a touch screen: real-time modelling of a complex and vast collection of objects such as raindrops in a cornfield is not your usual suspect for human computer interaction.

Hmm.

Exactly. You see, particles fascinate us because they are so refined and sophisticated, especially the way they move and evolve all together under our eyes. At least that is how we think of them. There is no way that the classic, digital, Boolean logic of interfaces such as the mouse or keyboard can help any human embrace their elaborate behaviour. Even the more complex, analog controllers such as the joystick or the Wiimote are not refined enough for millions of particles.



Fig.E

We have created the Dirty Tangible Interfaces (DIRTI) (cf. Fig.D) in order to tackle the



Fig.D

issue and be satisfied with the experience of controlling these particles.

Does that mean we need to get our hands dirty to control particles on the screen?

Not that dirty necessarily, but yes. Our interaction principle involves the users getting their hands in a sandbox (or chocolate, or ice cream, or anything that can be moulded and that is semi-transparent when spread). The infinite, 'natural' nuances of sand are just amazing to interact with. Scanning for density or movement of this material makes the sophisticated reality of our world interact with the machine. You can sculpt dunes, canyons, move a whole bunch of sand or just one tiny rock... it has immediate effect on the screen.

How does it work?

With a simple webcam for the PC version, or the embedded back camera of the tablet for the iPad version. Check out the videos on the website!

Any publications?

Glad you asked. We wrote an article ³ about the DIRTI that was published in the Proceedings of the 2012 edition of the NIME conference in Ann Arbor (University of Michigan).



Xavier Boissarie & Roland Cahen

Audio augmented navigation in 'Topophonie Mobile'



1. <https://itunes.apple.com/us/app/topophonie/id441138913?mt=8>

Fig.A. © Magali Bragard

Fig.B. Topophonie app for iPhone on iTunes store

Fig.C. © Magali Bragard : sound navigation

Fig.D. unlimited experience (photo Sylvia Fredricksson)

'Topophonie de l'eau' settles a poetic soundscape in a location of the urban space in order to modify the visitor's perception and reading. This soundscape complies with the topography and the functions of place. The piece invites visitors to an exploratory wandering and to perceive hidden dimensions of a familiar urban space.

'Topophonie de l'eau' works in Belleville Square in Paris.

A free app for accessing the experience can be freely downloaded from the app store under the name 'topophonie'.¹



Fig.A

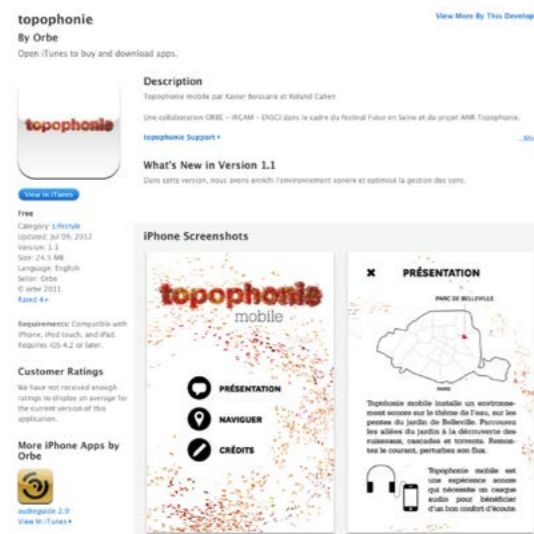


Fig.B

Flowing in hidden pipes within the aquifer, water is everywhere in the urban mineral space, although invisible.

The slopes of Belleville in Paris evoke the sinuous water up to the names of the streets: rue des Cascades, street gutters, rue de la Duée. Two realities overlap in this area: a mineral surface and a liquid invisible space, consisting of springs and underground aqueducts.

'Topophonie de l'eau' proposes to raise this liquid space up to the surface by staging a spatialised navigable soundscape. Visitors wander freely in liquid auditory streams, can go down or against the current, altering the sound. Sensations of gravity due to the slope combine with sound expression.

Water runs down the steep slopes, stagnates in ponds and rushes into the openings, trickles down the slopes. This soundscape is heard throughout visitors' ambulation.

Through their movements visitors disrupt the flows, create eddies and whirlpools.



Fig.C



Fig.D

Fig.E. sound map of Belleville square

Fig.F. PeintSon in situ editor interface

Fig.G. © Magali Bragard



Fig.E



The device is conceived for smartphones and programmed with Unity software, enriched by components developed within the framework of the Topophonie project:

The PointCloud is a structure of data defining a detailed sound map, as well as the sound IAE library developed by Ircam, which generates infinite textures of lively water sounds, from a reduced corpus of water samples. In addition, the device modifies the sound behaviour according to various terrain parameters, such as gradient, stream size, direction and speed of the visitor's movement in the stream, etc. As the sound generation is dynamic it changes all the time along the ambulation, just as if one was walking along a real stream.

'Topophonie de l'eau' displays three sound grounds: distant, intermediate and close. The produced soundscape offers a polyphonic and immersive experience. Equipped with an open audio headset, the visitor perceives a mix of outdoor sounds and those generated by the application. A cartographic interface indicates the visitor's position as well as the perimeter of the experience.



Fig.F

The mobile tool 'PeintSon' (SoundPaint) designed and developed by Orbe allows painting sounds on a map by moving in situ with a mobile terminal using GPS to be localised on the map. The programme actually works with water sounds, but can be used with any kind of content. The user selects the type of streams and draws his line in the public space with his own walking. The sounds of rivers are heard during editing as a polyphonic soundscape.

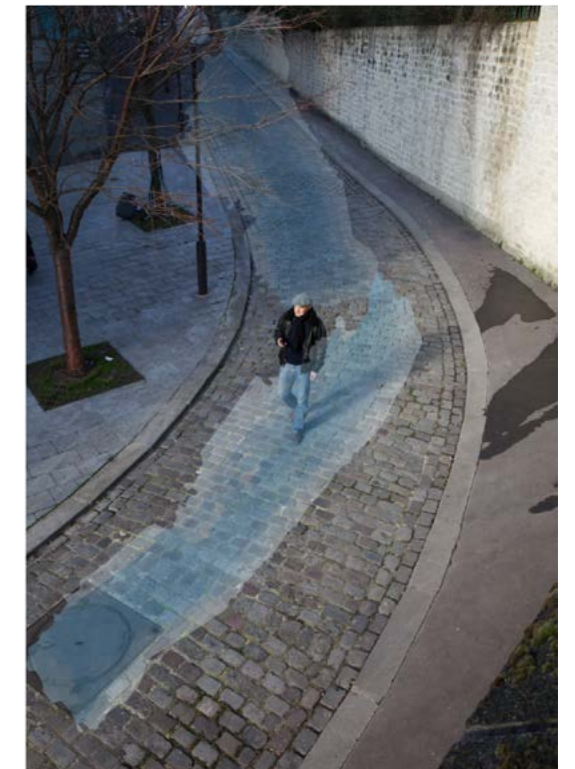


Fig.G



Philippe Perennez & Thomas Derambure

Applications for auditory maps

1. <http://www.navidium.com/topophonie>

2. Navidium was recently rewarded for its community mapping platform, by the Ministry of Education, as an application of acknowledged pedagogical interest.

3. Julien Beau did his internship at Navidis during the Topophonie project. He's an electroacoustic music composer, soundman in charge of collecting a sound library for Naviphonie software.

Fig.A. Extract of the different menus to create graphic elements and add base map to a project

Fig.B. Zoom about how the Audio Menu of Naviphonie works. It shows the different possibilities when the user wants to adjust the audio parameters.

In agreement with ENSCI, Navidis worked on the concept of auditory maps to provide sound information in maps, in order to give users an acoustic dimension in exploring territories.

Developed from the educational platform Navidium ^{1,2}, the software proposes to create a map of a territory through simple, ergonomic and fun tools (cf. Fig.A). A range of drawing tools enable to draw punctuals, linears and polygons. In addition, it is possible to enhance a project with 'rich media' like text content, photo or video. Finally, the user can load a base map from existing libraries, or upload his own content! (This may not necessarily be a base map, but a picture of a building, a landscape, etc.).

Working with ENSCI has allowed us to develop a sound module (cf. Fig.B) to give a new interactivity with the maps.

This module offers the possibility to add sound to any graphic design and attach one or more sounds from a library provided in the application.

When one or many sounds are 'attached' to one or several graphic / geographic objects, the module allows the user to choose how to activate



Fig.A

Different scenarios were tested with the platform Naviphonie : creation of artistic maps, urban atmospheres, maps in the context of a cultural event, awareness of noise pollution in residential areas.

One of the examples deployed on the platform was that of Julien Beau ³, who in addition to being in charge of setting up the sound library Naviphonie, made a map of urban environment of the city of Bordeaux. The aim of this map is to recreate the atmosphere in the city, particularly between the waterfront and the historic centre. With these audio recordings, browsing through the map transmits the various moods of the city as if the user was projected into the heart of Bordeaux (cf. Fig.C).

Another creation was a sonification of the noise pollution map of the territory of Nancy. This

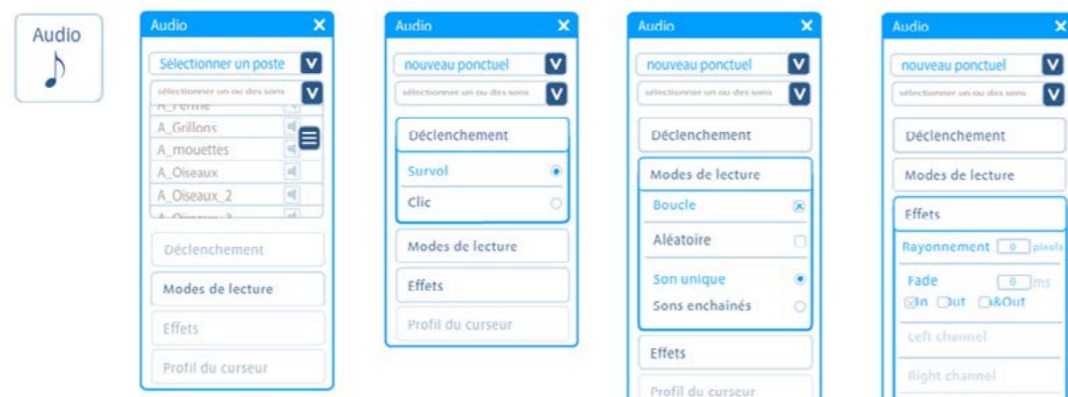


Fig.B

sounds (by roll-over, or left-click), to indicate playback mode (shuffle, loop), to manage the volume of each sound and apply audio effects (fade, radiation) to make the browsing experience unique.

example is intended to reuse a legal noise map study by the city of Vandoeuvre-Les-Nancy, make it interactive and submit it as a map for the general public to inform and educate urban residents about noise pollution to which they are subjected.

On the basis that the maps from such

Fig.C. View of the Julien Beau's project about the mood of Bordeaux's city centre.

Fig.D. Another exemple of a city atmosphere : Paris and the 'Quartier des Halles'.

Fig.E. Extract from the project about the noise pollution map of the city of Nancy. We can discover a complex cartography with electric colors that means the sound intensity in decibels. But thanks to the interactivity, the users can hear what could be the realistic situation of a noisy boulevard if he was on the pitch.

institutions were dedicated to an audience of technical and specialised profiles, we wanted to make the various interactive map areas by incorporating sound recordings from boulevards with dense automobile traffic or calm streets, narrow streets which can be as noisy as major roads, and parks where vegetation protects from the noise of the city, etc.

Playing on radiation effects as well as the loudness of each sound source, we recreated realistic urban atmospheres and attracted the attention of users.

The spectrum of auditory maps usage is underexploited, but thanks to the research work done by Navidis and ENSCI on this platform, new perspectives are open to auditory maps : maps for visually impaired, mapping for cultural events, transforming paper maps into interactive auditory maps to sensitize citizens about the noise of their neighbourhood, etc. These are just a few examples of what can be offered by Naviphonie.



Fig.C

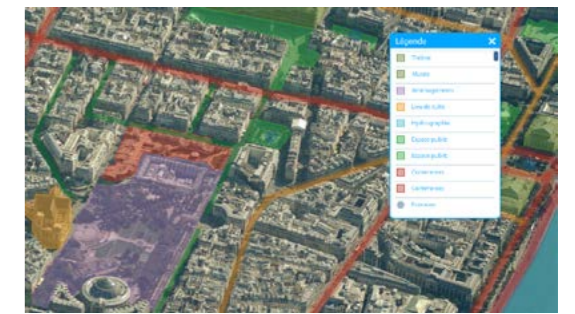


Fig.D



Fig.E

Jonathan Tanant

Topophony Unity software library

1. Information about releases will be provided on www.topophonie.fr

2. An octree is a tree data structure in which each internal node has exactly eight children. Octrees are most often used to partition a three dimensional space by recursively subdividing it into eight octants (en.wikipedia.org). We use it to find the nearest neighbours quickly and easily.

Fig. A Two mesh point clouds carrying audio data

Fig. B Clustering the foliage of a tree for Audio/Graphic LOD

The purpose of the software library¹ is to give an advance tool to designers and sound designers to create rich and flexible audiographic 3D scenes. The main features are:

- Non-punctual sound sources including terrain distribution
- Activators with profiles and management of causal sound actions
- Extended listener managing Audio/Graphic Level Of Detail

Dynamic sound generation using sampling, granular synthesis, unit selection and corpus based synthesis (ref. IAEOU)

The Topophonie project partners chose **Unity3D** as integration software platform, and the need for specific components not available in Unity came with the research, discussions and developments. A release on the Unity Asset Store is planned at the end of the project.

Unity3D is a 3D real-time author environment, such as Blender, Virtools/3DVia, etc. It is used for game design, simulation and other 3D interactive contents design. It can export application for most computers platforms, smartphones, gameboxes and the web. It is an open commercial platform used by numerous of developers worldwilde and amateurs benefiting from a free version.

A modular architecture

The **Topophonie Unity software library** is made of several modules that can be used independently or together to build rich audiographics multi-platform applications:

All modules can be easily connected with other existing Unity components and GameObjects.

The **point cloud** library allows to distribute data in **very large multimodal environments**.

An octree² optimises the search and parsing of these huge amounts of data: structure, making search faster thanks to spatial indexing. Point clouds can be linked to mesh morphs, providing a way to visualize the embedded datas.

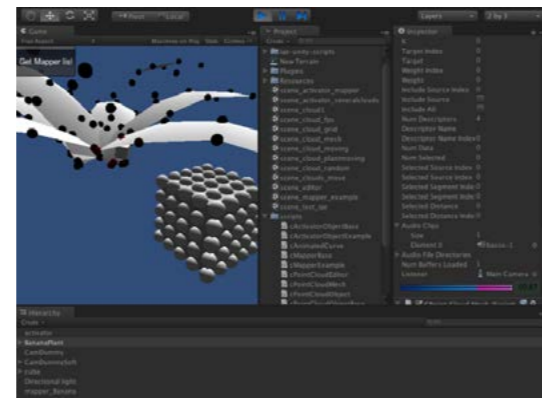


Fig.A

The **mesh processing** library is able to compute, from a high quality 3D model input, **simplified** lower level of details versions with several algorithms (clustering, decimation, 2D imposters, etc.), to make it suitable for different types of models: trees, characters, objects, animated or not, etc. The library is extensible in order to allow users to add their own algorithms.



Fig.B

The **LOD runtime** library implements mechanisms to switch efficiently and on demand between several **level of details**, according to the needs and processing power available at the moment and on the device (mobile or desktop). We classically use the distance between the object and the camera, but other modalities are available, such as on screen size, priority, etc.

The **SLOD** (Sound Level Of Detail) library contains a specific audio **clustering** logic: from a map (i.e. a point cloud) of all the audio sources

Fig. C Dynamic audio clustering (SLOD): dots are AudioSources and cylinders are AudioClusters

Fig. D Billboard planes on a tree at a certain Graphic Level Of Detail (GLOD)

Fig. E Sketch for 3D clustering

Fig. F Sound Level Of Detail in Topophonie Unity Editor

made by the designer, a clustering is computed with a listener profile. The clustering provides a way to adapt from the huge amount of audio sources (Unity classical AudioSources or IAE granular sources) to the limited amount of audio sources available, e.g., only 4 sources on iPhone.

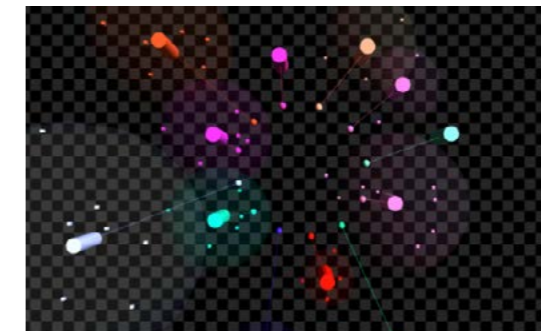


Fig.C

The **Topophonie framework** proposes a way to build rich audio-graphic applications, with components such as Actors and mappers. This is really the bridge between all the other components and forms the main architecture for applications built with this framework. Actors are logical entities with movement, ability to modify data. Mappers are entities giving a semantic meaning to data.

The mapper editor

The **Mapper and PointCloud editor** (developed with Nicolas Dacquay) allows the user to fill the point cloud with data and to build audio-graphic processes by adding mapping between input parameters (from the actors or the point cloud) and output parameters (audio synthesis, audio-graphic parameters and graphic dynamic behaviour).

The framework is interconnected with the **IAE** (IMTR Audio Engine Object for Unity3D)

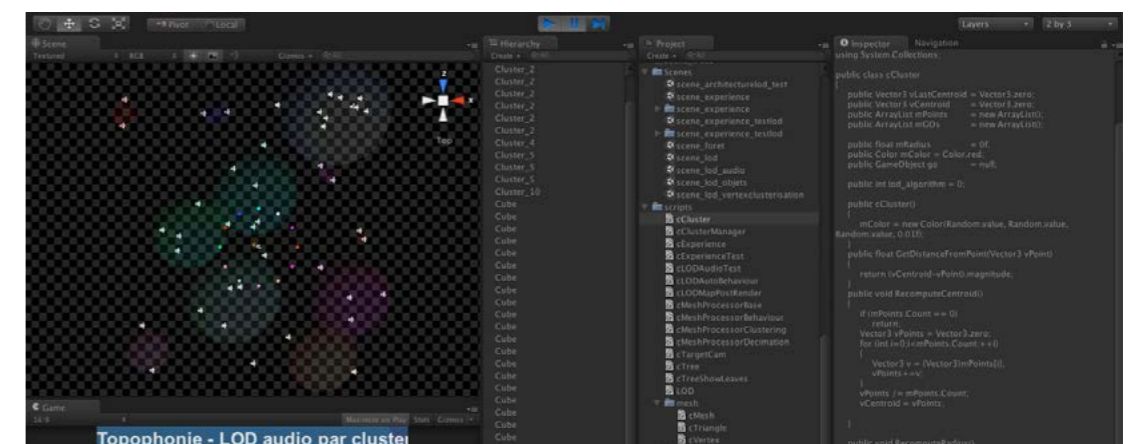


Fig.F

developed at Ircam by Norbert Schnell, Diemo Schwarz and Victor Zappi.



Fig.D

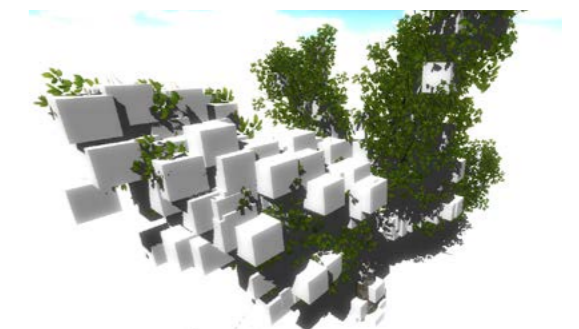


Fig.E



Norbert Schnell, Diemo Schwarz, Roland Cahen, Victor Zappi
IAE & IAEOU

Fig. A. Architecture of the IAE. The granular audio rendering engine accesses raw audio samples and segment descriptions that are either automatically extracted from the loaded audio materials or loaded from annotation files. The engine is controlled by a set of audio parameters that include both, the perceptual descriptor parameters and the granular audio rendering parameters.

The IMTR Audio Engine (IAE) is a versatile audio engine for content-based synthesis developed by the IMTR team at Ircam. As a portable library it has been integrated into platforms such as Max/MSP, Unity 3D and iOS. The IAEOU (IAE Object for Unity) developed within the Topophonie project in collaboration with the ENSCI and Orbe is a plugin for Unity 3D that integrates the IAE.

In Topophonie, the primary application of the IAEOU Unity plugin was to render sound textures within interactive audio-graphical environments, such as the sound produced by rain, flowing water, fire, wind, and foliage as well as traffic noise and crowds. Based on recorded sound materials, the engine facilitates the creation of highly interactive materials and objects as well as infinite ambient textures. The sounds generated by the plugin can responsively react to user actions and evolve with the behaviour of other audio-graphical elements within the created environment. The IAEOU can be further used to generate evolving and/or reactive musical textures and loops based on slowly evolving sounds, ambient sounds as well as percussive and rhythmic material.

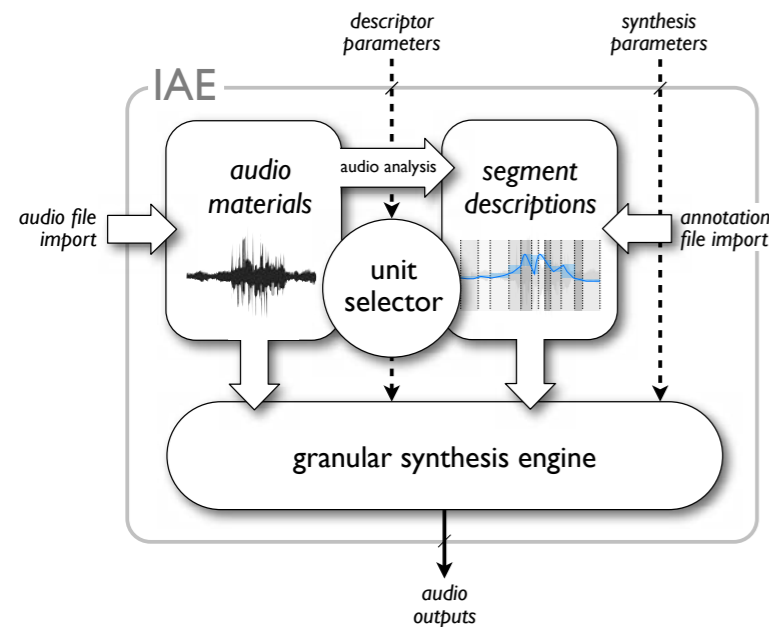


Fig.A

The IMTR Audio Engine

The IAE performs granular and concatenative synthesis on annotated audio materials. The annotations comprise a segmentation of each sound file into a sequence of sound segments – i.e. units – as well as parameters describing perceptual properties of each unit, such as its duration, energy, timbre, and pitch content. Depending on the audio content, a single unit can last a few milliseconds for short percussive sound events and transients, or a few seconds for longer sound segments.

The IAE can extract annotations automatically from the loaded audio materials or import them from files created by specialised analysis and audio editing software.

The engine has three synthesis modes. In granular-mode, it ignores all audio annotations and synthesises sound segments – i.e. grains – of arbitrary durations. In segmented-mode, the engine respects the segmentation of the audio files into units. In both modes, all loaded audio materials can be accessed randomly and at any speed with reference to their unit id or their position within the original unit files. Each synthesised sound segment (segmented unit or arbitrary grain) can be individually transposed, filtered, and distributed to multiple outputs with individual levels and delays for each output.

In descriptor-based mode, the engine is controlled by selecting units according to their perceptual description. In this mode, the audio materials can be seen as clouds of units in a multi-dimensional descriptor space unfolding over the dimensions of the perceptual descriptors. When navigating in this descriptor space, the engine can synthesise single sound events fitting a given description (e.g. energy and timbre corresponding to a particular position in the descriptor space), as well as complex sound textures and rhythmic structures that evolve according to perceptual parameters (e.g. corresponding to a particular trajectory in the descriptor space).

Fig. B. Example of an IAE audio sample annotated by segmentation markers, loudness and, pitch.

Fig. C. Overview of the IAEOU integrating the IMTR audio engine into a Unity plugin.

Fig. D. IAEOU editor in Unity: Granular synthesis editor.

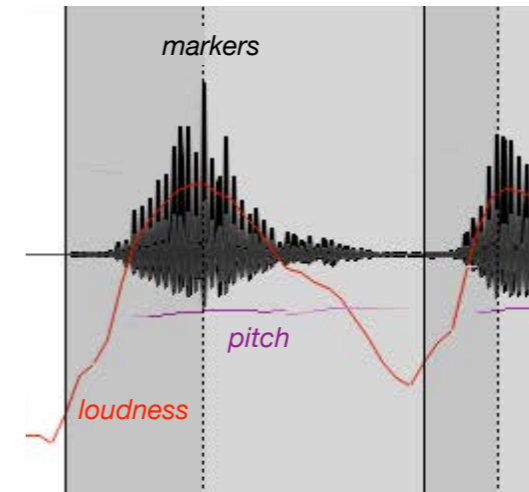


Fig.B

The IAEOU Plugin for Unity

The IAEOU allows a large number of virtual audio sources to be placed in a 3D scene – sources that are created and controlled as a single sound process via Unity’s graphical user interface or scripting facilities. The audio channels that output from the IAEOU can be spatialised as a Unity audio source.

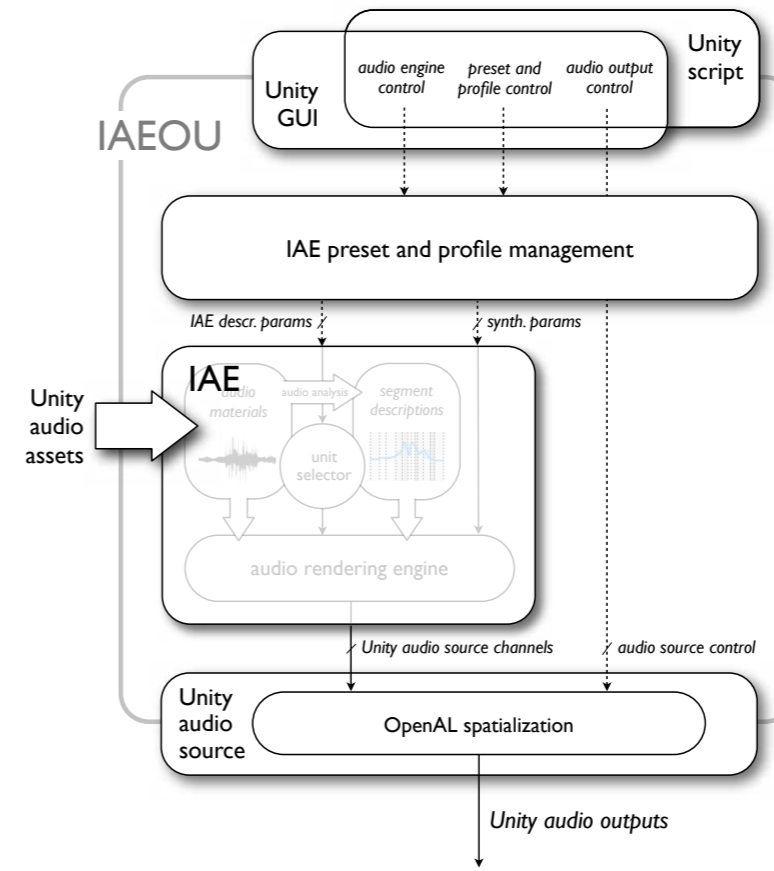


Fig.C

By abstracting IAE descriptor and audio rendering parameters by presets and profiles, audio-graphical processes can be created that are controlled by a common set of parameters related to their – audiovisual – appearance and behaviour.

In the Topophonie Mobile project the IAEOU plugin has been used to render interactive virtual sound sources based on recordings of water streams. The application mixes audio loops to generate a sound environment evolving as a function of the user’s position and orientation, with sounds reacting to the dynamics of the user’s movement as they are captured by the motion sensors of iOS mobile devices.

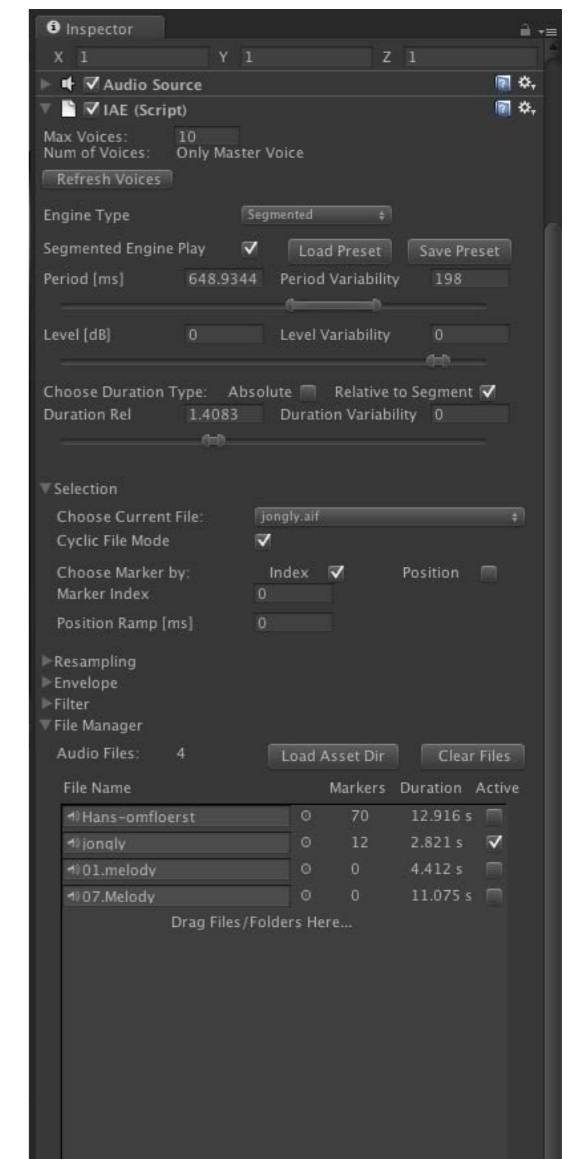


Fig.D

Afterword

The Topophonie project has been the turning point for our school of industrial design to enter into the world of research. As of yet, it is the first and only successful application for funding from the ANR (Agence Nationale de la Recherche) made by ENSCI-Les Ateliers, thanks to the dedication of the project director, the composer and sound designer Roland Cahen. Thanks to Topophonie, ENSCI has discovered its potential and ability to pioneer a new field of research: Design. This project has enabled the school to become the heart of a kind of research that operates on both creative and technological modes, in a field which is as rich as it is almost unexplored: Sound Design. Such research is both creative and scientific. It aims to:

- Discover new methods of exploration;
- Create new concepts which provide an architecture for inventing multi-modal objects;
- Develop means of industrial applications, which have already been pivotal in the development of new software.

Topophonie has also been instrumental in defining a pedagogy for research at ENSCI. One of the aims defined by Roland Cahen in the Topophonie project was to give student designers the opportunity to work in these experimental studios side by side with researchers, designers, computer scientists, composers and acousticians. However rigorous the research partnered by institutions such as Ircam and LIMSI - CNRS, the students always had their place. At ENSCI, digital culture is taught through experiments by treating code like material: our students have adapted this laboratory workshop setting to prototype new auditory situations.

This gave some very talented designers the opportunity to collaborate with musicians, composers, engineers, acousticians and programmers. For the artist-technicians, designer-researchers, engineer-musicians, new roles that cross the disciplinary divisions had to be reinvented.

The Topophonie project has ambitions to:

- Contribute to a conceptual architecture of the relations between sound and space;
- Create interfaces between virtual realities and possible empirical experiences; and
- Find sensorial aids for new multimodal situations such as the audio-graphic applications in Topophonie.

Topophonie is an attempt to model specific spaces, such as cities, a classroom, nature, which are now all multimodal. This means that the perceptions and actions we can commonly experience, like listening to rain, reading a map or going for a walk in the park, are transformed.

Everyone working on the project cooperated to invent new little worlds, divided into states, which enable us to map anew our representation of sound, which we had mistakenly believed to be only for our ears: Topophonie gives sound a spatial representation. It is through movement and touch that auditory faculties are taken for a rather troubling yet exciting ride.

Sophie Pène

Going further - links : hear & watch

Web sites

- Project website: <http://www.topophonie.fr/>
- All published videos: <http://vimeo.com/topophonie/>
- Published photos: <http://www.flickr.com/photos/topophonie>

Publications

- Antoine Berr
'Architectures végétales Navigables audiographiques'
<http://www.topophonie.fr/content/publications/27/file4fb001a7044e2.pdf>
- Alexandra Radulescu
'Mushrooms organic cities'
<http://www.topophonie.fr/content/publications/28/file4fb00657e5319.pdf>
- Dorine Lambinet
'Métropoles organiques audiographiques'
<http://www.topophonie.fr/content/publications/26/file.pdf>
- Diemo Schwarz
'Descriptor-Based Texture Synthesis Control in Interactive Audio-Graphic 3D Scenes by Activation Profiles'
<http://www.topophonie.fr/content/publications/14/file.pdf>
- Roland Cahen, Diemo Schwarz, Xavier Boissarie, Norbert Schnell
'Topophonie Mobile, an immersive audio interactive augmented experience'
<http://www.topophonie.fr/content/publications/13/file.pdf>
- Xavier Boissarie
'Topophonie Mobile au Parc de Belleville'
<http://www.topophonie.fr/content/publications/11/file.jpg>
- Léa Bardin
'Usages et enjeux de la cartographie sonore'
<http://www.topophonie.fr/content/publications/10/file.pdf>
- Roland Cahen
'Métrophonie, une maquette sonore pour des villes de demain'
<http://www.topophonie.fr/content/publications/9/file.pdf>
Semaine du Son 2010 (Palais de Tokyo - Paris)
- Marie-Julie Bourgeois
'Crossing foliage, an analytical and experimental approach of activation profile for audio-graphic navigation in foliage clusters'
<http://www.topophonie.fr/content/publications/5/file.pdf>
ISEA 2010 (Istanbul)
- Zoé Aergenter et Philippe Thibault
'Feuillage & flou'
<http://www.topophonie.fr/content/publications/7/file.pdf>
- François Bernard et Marjorie Priou
'NiveauDetailAudiographiqueFouleVisiteMusée'
<http://www.topophonie.fr/content/publications/6/file.pdf>
- Jonathan Renous
'RenduTopophonie_T1.Fluides'
<http://www.topophonie.fr/content/publications/8/file.pdf>
- Diemo Schwarz, Norbert Schnell
'Descriptor-Based Sound Texture Sampling'
<http://www.topophonie.fr/content/publications/3/file.pdf>
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In Proceedings of the Sixteenth Annual International Conference on 3D Web Technology, 2011.
- Hui Ding and Christian Jacquemin
'Palliating visual artifacts through audio rendering'
In Smart Graphics, pp. 179-183, 2011.
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'Spatializing Timbre with Corpus-Based Concatenative Synthesis, Wave Field Synthesis, CataRT, Max/MSP'
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- [Schwarz10b] Schwarz, D., Schnell, N.
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International Computer Music Conference (ICMC), New York, 2010, pp. 76–79
- [Einbond11a] Einbond, A., Schwarz, D.,
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Crossing the Corpus Callosum II: Neuroscience, Healing & Music, Cambridge, MA, 2011
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- [Schwarz11a] Schwarz, D.
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Sound and Music Computing (SMC), Padova, 2011
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'Sound Level of Detail in Interactive Audio-graphic 3D Scenes'
International Computer Music Conference (ICMC), Huddersfield, 2011, pp. 312–315
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'State of the Art in Sound Texture Synthesis'
Digital Audio Effects (DAFx), Paris, 2011, pp. 221–231
- [Einbond12a] Einbond, A., Trapani, C., Schwarz, D.
'Precise Pitch Control in Real Time Corpus-Based Concatenative Synthesis'
International Computer Music Conference (ICMC), Ljubljana, 2012
- [Lallemand12a] Lallemand, I., Schwarz, D., Artières, T.
'Content-based Retrieval of Environmental Sounds by Multiresolution Analysis'
Sound and Music Computing conference SMC2012, Copenhagen, 2012
- [Savary12a] Savary, M., Schwarz, D., Pellerin, D.
'DIRTI — Dirty Tangible Interfaces'
New Interfaces for Musical Expression (NIME), Ann Arbor, 2012, pp. 347-350
- [Schwarz12a] Schwarz, D.
'The Sound Space as Musical Instrument: Playing Corpus-Based Concatenative Synthesis'
New Interfaces for Musical Expression (NIME), Ann Arbor, 2012, pp. 250-253

Workshops conferences and public demos

- Futur en Seine 2011-2012
'Topophonie Mobile at Belleville square'
Orbe / ENSCI
- Futur en Seine 2012
'Conférence rencontre autour de la cartographie Sonore'
Le Cube Tuesday 19 June (Issy les Moulineaux)
- NIME 2011 workshop Oslo (Norway)
Audio-graphic Modelling and Interaction Workshop @ NIME2011
29 May 2011 (Universitetet i Oslo, UiO)
<http://www.topophonie.fr/event/1>
- DAFX 2011 workshop Paris
Audio-graphic Sound Synthesis Workshop
Versatile Sound Models for Interaction in Audio-Graphic Virtual Environments: Control of Audio-graphic Sound Synthesis
23 September 2011 (Ircam)
<http://www.topophonie.fr/event/3>

Apps

- **Topophonie Mobile** : free iphone app for sound navigation in the Belleville Square (Paris)
<https://itunes.apple.com/fr/app/topophonie/id441138913?mt=8>
- **Topophony Unity software library**
- **DIRTI for ipad**

Information about releases will be provided on www.topophonie.fr

ENSCI - Les Ateliers is the coordinator of the Topophonie Project.

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