

# On-line music distribution: a case study

[http://VirtualGoods.tu-ilmenau.de/2004/On-line music distribution: a case study pdf](http://VirtualGoods.tu-ilmenau.de/2004/On-line%20music%20distribution%20a%20case%20study.pdf)

Francis Rousseaux <sup>1</sup>, Alain Bonardi <sup>2</sup>, Romain Poncelet <sup>3</sup>.

<sup>1</sup> [francis.rousseau@ircam.fr](mailto:francis.rousseau@ircam.fr), IST SemanticHIFI European project team of the Institut de Recherche et de Coordination Acoustique/Musique (IRCAM) and the Laboratoire d'Etudes et de Recherches en Informatique (LERI) from the University of Reims Champagne Ardenne (URCA)

<sup>2</sup> [alain.bonardi@wanadoo.fr](mailto:alain.bonardi@wanadoo.fr), Intelligence Artificielle et Robotique Mobile (IARM) team from University of Paris 8 and Maison des Sciences de l'Homme Paris-Nord (MSH-PN)

<sup>3</sup> [poncelet@ircam.fr](mailto:poncelet@ircam.fr), IST SemanticHIFI European project team of the Institut de Recherche et de Coordination Acoustique/Musique (IRCAM)

**Abstract.** In this paper, we show how the practice of buying CDs surreptitiously conditions our musical activities, and how the practice of classifying a priori, making changes one at a time, structured by buying and the notion of genre, will disappear, as develops an ad-hoc organization of auditory samples, centered on prototypes and similarity. This movement is a proof of the loss of importance of the instantiation of CD marketing categories. Thus appears similarity-based calculus, acting on considerable masses of samples, which continuously change the balance of the man-machine dialogue, in an appeal started again and again to compare information. We also show how some artistic creations which rely heavily on computers, especially in the domain of inter-media theater, proceed in the same way, masking instantiation and developing the calculation of the similarity of the comedian's expressive faces. Art and culture are linked in processes that take advantage of their massive digitalization.

## 1 Introduction

Instantiation is often used by computer scientists, it refers to the word instance, which means example, case. Mathematicians use instantiation operations to assign a numerical values to variables. More concretely, computer scientists are instantiating abstract categories, issuing that a singular object belongs to an abstract category. Hole the abstract classes are linked to each other ([11]) as parts of an ontology (ontologies are assumed to describe parts of mundane knowledge, they are widely used in artificial intelligence) or sometimes as an object-oriented design (an object-oriented design is composed of inheritance graphs to produce computer programs simply by instantiation of key parameters). Here we can feel that choosing a fixed ontology to describe and index music is a very difficult task. Actually it may be impossible to reduce everybody's relation to music into a general view of musical categories.

An interactive computer device, based on symbol manipulation, works only if the two following conditions are met: on the one hand, programs starting an execution have a correct syntax, on the other hand, the user agrees to play the interaction game with the device, thus recognized as an operational fiction (unless one can believe that a

homunculus is hidden inside the computer, as a certain chess players used to be). Dealing with subjective classification, a music browser have to “fiction” more than instantiate.

## **2 NAVIGATING IN OCEANS OF MUSIC: A FASCINATING INDEXING PROBLEM**

Using a classification mode always implies more assumptions than it seems. That is why the issue of labeling and classifying is an old philosophical one, and studying it has never ceased to mobilize energies and to generate controversies ([1], [12]).

### **2.1 Today's craze for on-line music distribution**

If online music distribution made a lot of ink flown lately ([14]), it is because three circumstances allow social, cultural and business demands to persist and crystallize, and even to claim their importance as so many strategic industrial necessities:

- people who buys CDs do not understand why the Web, otherwise so generous with text and pictures, is still deaf to their appetite for music "à la carte," and they accuse CD companies to keep using an expensive and delicate medium, which also forces music amateurs to buy in advance materials which do not coincide precisely with their evolving and selective wishes ([13]);
- music designers fight to escape the normative constraints implied by CDs, to conceive the granularity of their artistic projects and to determine the development mode of their creative activities more freely, and to escape the classifying method based on the short-term impact of products on the markets;
- as for music producers and music companies, they are organized in a small number of multinational companies in competition (the famous Majors), and fear that a major innovation will disrupt their balance and crash one of the most profitable cultural markets —even if pirate copies erode it day after day).

Indeed, the technical and social study of the conditions necessary for the existence of online music distribution raises issues as diverse as managing and controlling the rights of digital materials (Digital Right Management) or the efficient networking of many client/ server machines of temporal data (possible on a peer-to-peer mode).

We will limit our study the question of indexing musical objects it means the study of the organization that would enable accessing and listening to music in a differentiated way, especially through the Web.

### **2.2 CDs surreptitiously condition our musical activities**

Let's consider the world of CDs — we will explain later this bombastic sentence. CDs are concrete materials containing sequences of musical pieces. Buying these concrete objects on the market is a necessary step to access their content.

To be able to sell CDs, it is necessary to display them, to label the shelves and the trays. It is not obvious at all, but the decisions taken here—very often implicitly—on the way CDs are organized, will have a considerable influence on the way our musical activities are established and organized, and especially on music listening, which is supposed to be so ineffable!

To be able to buy a CD, one needs to choose it among a great number, and this is usually done by walking around a warehouse where these objects are displayed in their cases, on shelves and trays, each tray being labeled to allow a meaningful arrangement of products. The goal is to make commercial exchanges easier by making a compromise between the physical constraints of the store, the clients buying habits, and the label readability. From a distance, it is difficult to identify CDs from each other, and the labeling system plays a very important commercial role. In that respect, a CD store is markedly different from a vegetable display, because vegetables can be immediately grasped for what they are, by their shape/color/smell/and even texture!

But the compromises made by department managers of record dealers rival each other in cleverness and originality—this is how some items are sometimes present in several different trays at once. For example, a new recording of Alban Berg by Pierre Boulez can be found in different departments:

- "new CDs";
- "classical/string quartet/Berg";
- "classical/conductor-Boulez";
- "special offers-Christmas/contemporary music."

Faced with such compromises, the promoters of the science of classification would often tear out their hairs, and botanists from the 17th century would not have endured such theoretical affronts. But business efficiency prevails in this case over scientific rigor, and systematic coherence matters less than productivity ([9])!

Partial typologies of sorts (time, instrumentation, composers, musicians, geographic/ethnic origins), as well as the incomplete ontologies are used to organize the editorial and commercial labeling of CDs. They rely on a background of scientific knowledge; but this knowledge is ultimately reorganized (grouped, specialized, generalized, improved, eluded, renamed) to suit for the practical goals they are made for: to facilitate the movement of goods.

Actually, marketing is conditioning the way to index CDs on the shelves of stores. Then everything follows this commercial classification. When a buyer recommends a CD to a friend who will potentially buy it, he will explicitly use the label categories, a semiotic system he learnt, without knowing it, walking around wholesale dealers...And the labeling device soon becomes part of a cultural heritage; it won't be long before it is used to describe the whole range of musical activities, including music listening itself, affected even in its most meditative modality ([18]).

### 2.3 From CDs to digital *sound files*

Some think that forcing descriptive labels into digitized sound files (which are now candidates for online distribution), is a good way to elaborate online music distribution services. These labels then become what is called meta-data—by this word, we mean that they are at the same time information, and description of information, just like the title of a book, or its table of contents are meta-data for the book.

This solution is not devoid of interest for the comfort and the cognitive handling for users of online services, because it allows them to question machines in the same way they were questioning labels until now. Walking around spaces cluttered with shelves is here simulated by using pop up menus and lists on a screen, which reused old descriptions without any adaptation, freeing music dealers from some constraints that are specific to the organization of physical spaces.

New problems will certainly arise when the time will come to organize the downloaded files, essentially from the file names (the file icons are not sufficient to organize properly large quantities of these objects, as François Pachet explained very clearly [10]). Who would force himself to perform such a tremendous task (a perpetual organization task, which even Sisyphus did not have to deal with), that a music department manager agrees to carry out only because he is paid to?

More generally, those who promote these solutions are not unaware of their built-in drawbacks: they know that the price to pay to maintain and update this meta-information is high, that chances are weak that automatic extraction from musical data becomes possible (until now, the automatic generation or the possibility to find automatically labels was not the main demand of organizers,<sup>1</sup>) and that the labeling system itself must first be rationalized to become compatible with a computerized processing (our machines are even more rigorous than 17th century botanists!)

But they often fail to understand the most reactionary aspect of their viewpoint. If we follow Gilbert Simondon and his theoretical proposal on the existence mode of technical objects ([16]), when mechanisms of online music distribution will come into being, they will inexorably forget these temporary solutions ...

Actually as the use of CDs becomes obsolete, why would we continue to use the troop of descriptors that were built to answer the outdated need of facilitating the movement of these commercial items? In a way, our (pseudo) taxonomies of today will soon only evoke a bygone era of the time when buying CDs supposedly made easier the connection between amateurs, consumers, producers of all sorts and music.

Drawing our inspiration from Simondon, we can hypothesize that with the loss of interest for CDs and the end of the requirement to buy the medium before listening to music, we will witness the corollary fall of an operational fiction, that was simplistic, but effective nonetheless: the object of the fantasy will not be to access the CD anymore, but the piece of music, or the sample, in a way that we must clarify. Because other forms of musical

---

<sup>1</sup> I suppose a truck farmer could put his apples through a riddle so they could be stored by *caliber*, but I have never seen it done on any market... However, another example may be more up-to-date: a chipset that will automatically label the *ripeness* of a piece of fruit by detecting typical flavors will soon be marketed...

activities will emerge to make possible the organization of musical objects, which will be more often dedicated and signed, and other ways of listening, crossbred with production. Thus the normative activity of CD buying will give way to situated actions, that will be part of more and more differentiated and singular projects.

## **2.4 The object/activity/description triad**

This is what we meant when we wrote about "music-ripping" ([3]), to note that when talking about signed listening, when listening means listening/composing/producing, then its object becomes the elementary unit of listening/composing/producing, a sample.

What is the array of listening situations? Will it be necessary to try to define it by referring to professional practices or amateur practices (the way a composer listens when he is trying to compose, the way anyone listens to music in his shower in the morning, the way a DJ listens when he is trying to put together a sequence). No, because these stereotypes pertain too much to the ancient era and say nothing about the world of listening as signed ([5]), which causes appropriations and mediations

Therefore, other typologies of signed listening situations will emerge shortly, because they are going to be enabled by the emerging technical systems of indexation and navigation ([19]) It will stimulate us to imagine our personal signed listening instead of reusing the old CD nomenclatures/ontologies which filtered scientific knowledge. The practice of classifying a priori, making changes one at a time, structured by buying and the notion of genre, will disappear, as develops an appropriate organization of auditory samples, centered on prototypes and similarity, situated in the singularity of everyday practice.

## **3...USING CALCULATION THOUGH STAYING THE MASTER OF THE GAME: LESSEN THE IMPORTANCE OF INSTANTIATION**

### **3.1 Instantiation as a calculation *incitement***

The fact that instantiation has not been reflected upon in computer science is not without serious consequences on thinking and research in computer science.

First, the spontaneous assimilation of singularities to particulars linked to devices of conceptual meshing sends back to these devices the task of representing and simulating reality. This is how research in computer science wears itself out setting up devices, forgetting from the start that their specifications are prescribed underground by the attempt to compensate for the obscurity of the operations of instantiation. This probably explains the infinite development of research on the representation of knowledge and ontologies, which aims at materializing (by category differentiation) devices that are supposed to be able to give light to a black hole.

Second, the consequence of the practice of computer scientists is often to soften and lessen the importance of the operations of instantiation, as if to veil its non-thought nature. Even if it is rare for a computer scientist to claim this inspiration explicitly—Frédéric Drouillon however places it at the heart of his creative work, by assuming that is possible to shy away from instantiation by stealing already instantiated systems to enroll them in more complex systems, it often operates as background to research ([17]).

Among the implicit means that enable designers of computing systems to lessen the importance of instantiations, there is one that relies on a heuristic meaning of calculation and on a vision of the request-calculus interactivity which is on the edge of contradicting Turing's hypotheses on the investment of the machines' minds by dialog, which is at the source of their reputation of intelligence. In the context of searching for digital content by similarity, this means is usually used.

Because when a calculation is used in order to organize a great number of digital entities according to their similarity to a specific example, the symbolic interpretation of the calculation and of the symbols that are used for it must be given up, and the only possible outcome is its heuristic efficiency in selecting particulars, proposed as so many candidates, which undergo a singular election to be accepted by a user. This is how the fundamentally heuristic nature of the resulting similarity-based calculus is expressed—an instance always corresponds to any singular demand, when chosen among the many particular candidates.

It is necessary to add that the user does not have to make a definite choice, but that on the contrary, he is encouraged to perform again his gesture of heuristic inquiry by similarity, starting with a new singularity and if necessary with new specifications criteria of the desired distance. Therefore, in repeating the gesture of aided selection, an evanescence of instantiation continues, sliding from selection to selection. And the dialog with the calculation is not part of Turing's intuitions, somewhat similarly to how the balance of a "balanced" chemical reaction can always be displaced by withdrawing progressively the material resulting by one of the two ways of the reaction. Balance is meta-stable. The other side of calculation is of no interest to the user, who does not try to build its model, but only to profit from it dynamically.

### **3.2 Heuristic and meta-stable similarity: a growing mobilization of calculation**

Let's come back to the example of online music distribution and the fantasies it creates. At the time of CDs, the activity of buying CDs is what conditions the indexation system, which relies entirely on a business goal, even if it is inspired by scientific classifications, and sometimes borrows them for local practices (but its local nature says enough about the subordination of every musical activity to the activity of CD buying). Let us note, to end this discussion, that a good CD dealer uses non-formal induction to set his selling mechanisms.

The contents are digitized, and the CDs as mediums are disappearing, thus ending the supremacy of the "buying containers" activity de facto. It is therefore useless to keep calling up indexes obviously linked to practices of bygone days, which will thus lose their evoking power very fast. Inevitably, the activities around searches for on-

line data will focus on ad hoc nuclei and idiosyncratic goals, which will closely unite reception and action, perceiving and doing, and thus determine their own objects, which we call samples here to note clearly that these objects are not preferably musical pieces or CDs ([3]).

In a correlative way to the emergence of idiosyncratic and ad hoc activities, the a priori indexation is gradually replaced by a dynamic indexation, and its central paradigm is usually similarity. But the dynamic construction of similarities can only be effective if done with formal calculation and carried out on a Turing machine. Therefore, this implies a need for algorithms to calculate descriptors on the basis of digital contents, and an attempt to match these (self-extracting) descriptors to appropriate categories in the context of committed ad hoc activities.

Indexation devices can then be composed from meta-information, but also from labels calculated from musical contents. The MPEG7 and MPEG21 norms thus propose to put on the market descriptors created from automatic extraction procedures and names that identify descriptive qualities.

#### **4...DRAMA INTERLUDE: TWO WAYS OF USING INSTANTIATION IN THE INTER-MEDIA PLAY LA TRAVERSÉE DE LA NUIT - CROSSING THE NIGHT**

##### **4.1 Instantiating with neural networks the expressive faces of a comedian on stage**

While Frédéric Drouillon suggests ([6]) an original kind of play where an artist comes to read artistic "oracles" in programs, we will here study the other side, the interactivity between a comedian or a singer on stage and a computer supposed to read intentions or to extract artistic moments from the comedian's acting. To paraphrase the lyrical singer José Van Dam <sup>2</sup>, what needs to be invented is a machine that would distinguish "between singers on one side, and artists on the other," and that would use as criteria the artistic "truth" [15] of the comedian's way of acting.

The inter-media theater play <sup>3</sup> *La traversée de la nuit* by Geneviève de Gaulle ([8]) is a sketch of how such a device could be used. The text is the story of the author, imprisoned in the dungeon of the concentration camp in Ravensbrück. It is a work on memory, on its processes, on mental states in the short, medium and long term. The work on memory is here linked to a neural network, which is used to recognize the emotional states from the voice of the comedian who says the whole text.

Neural networks are a clever and fashionable way to conceal instantiation—its importance needs to be lessened, or it should be avoided altogether. At least, it should not be detailed, by relying on the "calculation" processes of

---

<sup>2</sup> quoted by the director Pierre Strosser in the opinion column « Autour de l'opéra » in the issue entitled *Opéra et mise en scène* of the magazine « Musical », published by the Théâtre du Châtelet, 1989.

<sup>3</sup> Play performed on November 21st, 22nd, and 23rd at the Center for the Arts at Enghien-les-Bains (95). Director: Christine Zeppenfeld; comedians : Valérie Le Louédec et Magali Bruneau; multimedia design : Alain Bonardi et Nathalie Dazin; music : Stéphane Grémaud; lights : Thierry Fratissier.

similarity. As a reminder, a neural network is a computer device based on a much simplified model of the association of neurons, weighted so as to allow the recognition and classification of phenomena.

The network learned in the following way: for a few months, the comedian Valérie Le Louédec has declaimed her text in front of the computer, in pre-set moods: joy, sadness, resignation, anger, etc. After choosing a mood, the comedian tries to say the text in that state, no matter what the meaning of the text implies. For every pronounced sentence, a vector of twelve components is extracted from her voice: four of them are about the pronunciation of vowels (formants), four of them represent the noise generated by the consonants, and the four other parameters describe the prosody (the voice's range in the sentence).

Then these twelve-component vectors need to be linked to the intended emotional state, and this is the learning phase for the neural network. Hundreds of thousands of vectors are presented to the network in supervised mode, a comparison is made between what the network recognized and what it should have recognized, and the weight of the neuron connections evolve such as to make the difference between the two as small as possible. Thus, alternatively to an explicit model of an emotional state, a neural network is meant to set similarity conditions statistically. The process of establishing similarities, by constituting categories of equivalence, is based on the massive repetition of the experience of the phenomenon. Similarity ends up being shaped after many repetitions.

When the comedian is rehearsing or acting, the neural network "makes every effort" to recognize immediately the states of the comedian's voice. The quest for similarity continues—the goal is to recognize emotional states that have been previously memorized.

In the two cases, learning and recognition, there is not any real dialog man-machine in the traditional sense of question and answer, but a frantic solicitation of one by the other. While learning, the neural networks constantly appeal to the comedian; during recognition, the comedian is the one who appeals to the network relentlessly, to adapt her acting to what is stable and what changes. In both cases, one does not listen to the other, in the classical meaning of a dialog, but one works from what the other throws back at the other. A singular interactivity is established, entirely based on the hypothesis that the interactive similarity search will produce an interesting retrieval, and on the stimulation of the active-retroactive loop by immediately taking in any communicated result.

## **4.2 Instantiating a collaborative graphic generator**

These technical details should not make us forget the main goal of the device in this play, which is to make sure that the comedian's voice runs the character's "mental images," which are projected on the screen at the back of the stage, on a vast cyclorama (30 by 16 feet).

To this goal, the designers had first imagined to program animations of the picture, that is to say pre-defined pictures that move and change according to the results of the neural network presented above. Using the usual procedures of software engineering, this approach was intended to conform the calculation on the picture to the

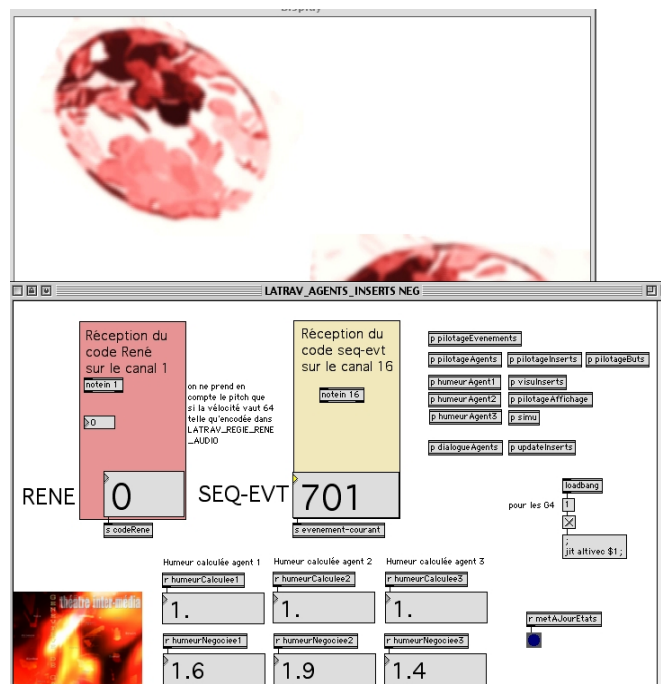


specifications of the director. But this first try was not judged satisfactory, because it gave too predictable and linear results, similar to the moving-sliding of objects in video games.

The demands of artistic expression thus lead the designers to lessen the importance of instantiation, to give up the classical way of expressing and specifying the need, which worked by linking the singularity of the director's creation to the particular of computing graphics, linked to the semantic network of vector and matrix calculation.

Therefore autonomous agents were used to build the picture at the back of the stage in a collaborative way. These agents should be pictured as bill-posters who would work together to create a poster from fragments of images that would be given to them, along with the goals of the sponsor. Therefore, at one moment in the play, the goal can be to have the biggest image possible, of the most transparency, or as much light as possible, etc. The goal is to create an artistic content by solving an optimization problem, following a method well known by the algorithm specialists (the gradient method).

Each of these bill-posters is modeled according to a few variables, inspired by psychology, which correspond to different states of the voice (recognized by the neural network) which increase or decrease a variable, according to its "mood". These moods modulate the agents' "zeal" to carry out their task. Figure 1 shows two agents driving pink rounded shapes.



**Figure 1.** Two autonomous agents carrying picture fragments in La traversée de la nuit (source: Alain Bonardi).

The results produced by this generative device that is given goals are amazing in terms of the distortion and movement of the image. Across performances, the movements on the screen are completely different, but they are always somehow "harmonious". This technical invention has also changed the relationship between the computer and the members of the project. The autonomous agents device was first encoded, and then suggested to the director and to the comedians, who contributed specific goals given for each sequence, without changing the details

of how the image is distorted and moved, which is not possible. The comedians adapted their acting to the mechanism. Figure 2 shows an example.



**Figure 2.** Example of a generation of images on the screen at the back of the stage in *La traversée de la nuit* (Valérie Le Louédec on the left, Magali Bruneau on the right; photograph: Julien Piedpremier).

In the case of this multi-agent system, calculation is also similarity oriented, since artists are asked to compare different proposals made by the computer. The system gains value with more experiences, through rehearsals and performances. The director and the comedians have the ambition to stage the show a hundred times, to make the text and their interpretation of it known, but also so they will "get to know" the generative system better, and to "play" with it more.

Some drama categories are thus displaced or questioned by this way of accessing artistic expression according to similarity and repetition. The text of the play was long given as the only input towards expression and emotion. Some texts have led to a great number of analyses, according to different models, and some of them have led to computer programming ([2]).

Doing away with the text as the only medium, and especially by using the medium of digitized voice, the processes that we have described, based on the establishment of similarities, pave the way for the creation of new drama emotions, and maybe new ways of theater creation and distribution with digital devices, provoking new uses for it. As with the distribution of musical contents by the Web, the auditory signal, its descriptors, the organization of "drama" contents with databases and MPEG norms that could be imagined, would reorganize the connection between theater and the audience<sup>4</sup>.

## 5...CONCLUSION

We have shown how the distribution of digitized music does away with the dominant paradigm based on buying CDs for a dynamic indexation centered on the notion of similarity. This change is the proof that the instantiation of the categories of CD marketing are given less importance. Thus appears similarity-based calculus, acting on considerable masses of samples, which continuously change the balance of the man-machine dialogue, in an appeal

started again and again to compare information. We have also shown how some artistic creations, especially in the domain of inter-media theater which relies heavily on computers, proceed in the same way, masking instantiation and developing the calculation of the similarity of the comedian's expressive faces.

These prospects open many research avenues, building bridges especially between the search for content and artistic creativity. Great disruptions in the domains of culture and art, now intertwined by their massive digitalization, can be foreseen.

## REFERENCES

1. Aristote, *Métaphysique*, Garnier Flammarion, 1993
2. Thomas Beurivage, *Exploiter des données morphosyntaxiques pour l'étude statistique des genres – application au roman policier*, Revue Traitement automatique des langues, volume 42, n°2, texte accessible à l'URL [www.atala.org/tal/](http://www.atala.org/tal/), 2001
3. Alain Bonardi et Francis Rousseaux, *Music-ripping : des pratiques qui provoquent la musicologie*, Musicae Scientiae, 2004
4. Alain Bonardi et Francis Rousseaux, *Composing an Interactive Virtual Opera : The Virtualis Project*, revue Leonardo, Journal of the International Society for the Arts, Sciences and Technology, volume 35, numéro 3, pages 315-318, 2002
5. Nicolas Donin, *Towards Organised Listening: Some Aspects of the Signed Listening Project at Ircam*, Organised Sound, Cambridge University Press, à paraître en 2004
6. Frédéric Drouillon, *Le calcul de la beauté : le principe de Pinocchio*, actes du séminaire STP de la MSH Paris, 2003
7. Eugen Fink, *Le jeu comme symbole du monde*, Les Éditions de Minuit, 1966
8. Geneviève de Gaulle, *La traversée de la nuit*, Éditions du Seuil, 1998
9. François Pachet, *A Taxonomy of Musical Genres*, RIAO, Paris, avril 2000
10. François Pachet, *Nom de fichiers : Le nom*, actes du séminaire STP de la MSH Paris, 2003
11. Jean-François Perrot, *Des objets aux connaissances*, Journée Méthodes objets et Intelligence Artificielle : Frontières, Ponts et Synergies, Paris RIA, juin 1994
12. François Rastier, *Sémantique pour l'analyse*, Masson, Paris, 1994
13. Francis Rousseaux, *Pourquoi le Web resterait-il sourd à nos envies de musique et de son ?*, MEDIANET, Monastir, 2002
14. Francis Rousseaux, *La notion d'œuvre à l'heure de la musique en ligne : comment concevoir la nécessaire médiation des affinités électives ?*, Klincksieck Editions, 2002
15. Francis Rousseaux et Alain Bonardi, *Vagabonds, pédants ou philistins : choisir en beauté*, in Art lyrique et art numérique, Observatoire Musical Français, Série Conférences et séminaires n° 13, 2002
16. Gilbert Simondon, *Du mode d'existence des objets techniques*, Aubier, 1989
17. Hamid Seridi et Herman Akdag, *Approximate Reasoning for Processing Uncertainty*, Journal of Advanced Computational Intelligence, vol. 5, n°2, Fuji Technology Press, 2001
18. Peter Szendy, *Ecoute, une histoire de nos oreilles*, Éditions de Minuit, 2001
19. Hugues Vinet, Perfecto Herrera et François Pachet, *The Cuidado Project*, actes des conférences ISMIR, Paris, 2002

---

<sup>4</sup> We have partially studied this kind of reorganization in the case of digital opera, cf. [4].