FP6-NEST-PATH project no: 29085
Report Version: 1
Report Preparation Date: May 25, 2007
Classication: Pub.
Deliverable no. 6.2

Closing the Loop of Sound Evaluation and Design (CLOSED)

Deliverable 6.2

Project Related Publications

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Contents

Introduction

The CLOSED (Closing the Loop of Sound Evaluation and Design) consortium submitted twelve articles from the beginning of the project in June 2006 until June 2007. These twelve papers are listed as follows:

1. P. Susini, N. Misdariis, G. Lemaitre, O. Houix, D. Rocchesso, P. Polotti, K. Franinovic, Y. Visell, K. Obermayer, H. Purwins, K. Adiloglu: Closing the Loop of Sound Evaluation and Design, Proceedings of the Perceptual Quality Systems, Berlin, Germany, 2006.

2. Y. Visell: The Sensual Move: Gesture Learning and Sensorimotor Interaction Design, ACM International Conference on Multimodal Interfaces (ICMI), Banff, Canada, 2006.

3. Y. Visell, J. Cooperstock: Modeling and Continuous Sonification of Affordances for Gesture-Based Interfaces, Proceedings of the International Conference on Auditory Displays (ICAD), Montreal, 2007.

4. K. Franinovic, D. Hug, Y. Visell: Sound Embodied: Explorations of Sonic Interaction Design for Everyday Objects in a Workshop Setting, Proceedings of the International Conference on Auditory Display (ICAD), Montreal, Canada, 2007.

5. D. Devallez, D. Rocchesso, F. Fontana: An experimental evaluation of the influence of auditory cues on perceived visual orders in depth, Proceedings of the International Conference on Auditory Display (ICAD), Montreal, Canada, 2007.

6. S. Delle Monache, P. Polotti, S. Papetti: Gamelunch, a physical-based sonic dining table, Proceedings of the International Computer Music Conference (ICMC), Copenhagen, Denmark, 2007.

7. F. Fontana: Preserving the Structure of the Moog Vcf in the Digital Domain, Proceedings of the International Computer Music Conference (ICMC), Copenhagen, Denmark, 2007.

8. K. Franinovic, Y. Visell: New Musical Interfaces in Context: Sonic Interaction Design in Urban Settings, Proceedings of the International Conference on New Interfaces for Musical Expression (NIME), New York, USA, 2007.

9. Y. Visell, J. Cooperstock: Enabling Gestural Interaction with Tracking Dynamical Systems Models and Assistive Feedback, Proceedings of the IEEE International Conference on Systems, Man, and Cybernetics, Montreal, Canada, 2007.

10. S. Papetti: The Sounding Object: estensione dei modelli di sintesi basati su impatto e frizione (an extension of impact and friction sound models), Proceedings of the XVI Colloquio di Informatica Musicale (CIM), Genoa, Italy, 2007.

11. F. Fontana and D. Rocchesso: Auditory distance perception in the acoustic pipe, accepted for publication in ACM Transactions on Applied Perception.

12. C. Drioli and D. Rocchesso: On the use of Kernel-based methods in sound synthesis by physical modeling, accepted for publication in Numerical Algorithms.

The first article was published on the Second ISCA / DEGA Tutorial and Research Workshop on **Perceptual Quality of Systems** (PQS), which was held in Berlin, Germany in the year 2006. This publication summarises the vision of the CLOSED consortium and the aim of the project. This publication is a co-operation of the whole consortium. Hence the authors of this article are: Patrick Susini, Nicolas Misdariis, Guillaume Lemaitre, Olivier Houix (IRCAM); Davide Rocchesso, Pietro Polotti (UNIVERONA),Karmen Franinovic, Yon Visell (HGKZ); Klaus Obermayer, Hendrik Purwins, Kamil Adiloglu (NIPG). It appeared in the proceedings of the Perceptual Quality of Systems workshop in the year 2006 in Berlin, Germany.

The other publications summarise basically the progress made by the partners during the project. They will be introduced during the year 2007 on several conferences all over the world. Among them two of the articles have been accepted by reviewed journals like ACM Transactions on Applied Perception and Numerical Algorithms. These articles will appear in the following issues of these journals.

The second article appeared in the proceedings of the **International Conference on Multimodal Interfaces** in Banff, Canada in 2006.

The following articles will be presented in the year 2007. They have not appeared yet.

The third, fourth and fifth articles will be published on the **International Conference on Auditory Display** (ICAD) in Montreal, Canada, in 2007.

The sixth and seventh articles will appear in the proceedings of the **International Computer Music Conference** (ICMC), in Copenhagen, Denmark, in the year 2007.

The eighth article will be presented on the **International Conference on New Interfaces for Musical Expression** (NIME), in New York, USA, in 2007.

The ninth article will appear in the proceedings of the **IEEE International Conference on Systems, Man, and Cybernetics** (SMC), Montreal, Canada, in 2007.

The tenth article will be published in the proceedings of the XVI Colloquio di Informatica Musicale, in Genoa, Italy in 2007.

The last two articles have been accepted by two journals, which are respectively **ACM Transactions on Applied Perception** and **Numerical Algorithms**.

The research fields, which the CLOSED project is interested in, and the way of posing the problems, which the CLOSED project deals with, raise several very interesting side questions as well. Especially increasing the convenience of the physical models, by using audio-visual interfaces, improves the quality of the sound designs. The designers can also embed the digital filtering techniques to develop better sound processing tools. These questions lead the consortium to pursue research on these side problems, to improve the quality of the solutions to the main research topics of the project, and come to some valuable results, which are worth publishing. Therefore, it is plausible to classify the publications listed above as *directly related publications*, and as *indirectly related publications* to the project. The directly related publications are 1, 2, 4, 6, 8, 10, 11, and 12. Whereas the indirectly related publications are 3, 5, 7, and 9.

To illustrate the content of these different kinds of publications, some abstracts are reported in the following sections.

1 Directly Related Publications

1.1 Closing the Loop of Sound Evaluation and Design

In this article, the authors indicate that despite being a promising and lively playground, sound design is not a discipline as solid and established as visual or product design. It is believed that the reason is to be found in the lack of design-oriented measurement and evaluation tools. The CLOSED consortium aims with this project at providing a functional-aesthetic sound measurement tool that can be profitably used by designers. At one end, this tool is linked with physical attributes of sound-enhanced everyday objects; at the other end it relates to user emotional response. The measurement tool will be made of a set of easy-to-interpret indicators, which will be related to use in natural context, and it will be integrated in the product design process to facilitate the control of sonic aspects of objects, functionalities, and services encountered in everyday settings.

This contribution summarises the state of the art of sound design and evaluation. During the last fifteen years, many research projects addressed sound quality measurement. Most of these projects could characterise the acoustic preference, but failed to account for emotional and cognitive processes related to the functional-aesthetic aspects of a product. There the consortium indicates that the present knowledge is insufficient, where relations between physical characteristics and perceptual descriptions are concerned.

Therefore in the following part of the article, the consortium proposes his own solution to the problem. According to this proposal, the key to closing the sound design loop is to develop suitable measurement tools and criteria. This idea is going to be pursued by the whole consortium by structuring the project itself as an interactive design process.

The scenarios from everyday context and design concepts for product sound enhancement will be developed. Sound-enhanced artefacts will be produced. These artefacts will be designed so that each one will represent the salient, physical, interactive, and sonic features of an interesting sound class products. Subsequently, the functional-aesthetic qualities of these products will be evaluated, and these evaluations will be used to design measurement tools, which will be engineered to infer the salient features relevant to human emotional response to the utilised sound models.

To summarise, this article introduces the aim of the consortium with the CLOSED project, and the approach will be (has been) used to reach this aim. In three years (two years from now), it is expected that a discipline of product sound design will start to emerge, to be practised, and to be taught.

1.2 Sound Embodied: Explorations of Sonic Interaction Design for Everyday Objects in a Workshop Setting

This article describes the sonic interaction design, which is a new discipline that concerns the use of sound as one of the principal channels conveying information, meaning, and otherwise affecting the experience of interactive artefacts or systems. It is positioned at the intersection of auditory display, product interaction design, and ubiquitous computing. In the article, an exploration of this field is described, which has been undertaken in an international workshop.

The article describes the sonic interaction design thoroughly. This description section is followed by the details of the workshop.

The authors argue for a strengthening of research at the intersection of auditory display and sonic interaction design for products, based on a certain set of goals aimed at satisfying design driven needs for interactive sonification in everyday artefacts.

The workshop organised by the authors aimed at researching new roles for auditory display in product interaction design, and at exploring related opportunities and use scenarios. Sonic interaction design methodologies were investigated in the workshop, which can be integrated into some design practices. The main approach of the workshop was based on learning through experience. Special topics in sound and design were tempered with field research and direct sensory exploration. Subsequent to the lectures, participants formed project groups, and pursued co-operatively to reach their goals that varied according to their interests and background knowledge. Interviews with the participants revealed useful feedback about the workshop as well as about sonic interaction design. As a result, new methods capable of assisting designers with the many tasks involved in designing for auditory display in everyday artefacts.

The authors plan a series of such workshops in order to investigate this new emerging field of sonic interaction design.

1.3 Gamelunch, a physical-based sonic dining table

In this paper, the authors introduce the gamelunch, which is a sonically augmented dining table. The work aims at exploiting the power and flexibility of a physically-based models approach, in the investigation of the closed loop between interaction, sound and emotion, from the point of view of an energetic consistency or, better to say, inconsistency throughout the chain "gesture → (inter)action → sound → perceived sound → information / emotion → gesture". By means of contact microphones and various force transducers, continuous gesture interaction is captured to provide energetically coherent information to a set of physically-based soudn synthesis algorithms. Durin his dining-based interaction, the user, performing usual actions, directly manipulate a contradicting and unexpected sonic feedback, thus experiencing *a contrario* the importance of sound in everyday-life acts.

1.4 The Sounding Object: an extension of impact and friction sound models

In this paper, Stefano Papetti presents a reworking and an expansion of some outcomes of the EU project SOb (The Sounding Object) [IST-2000-25287]. During the project SOb, several physically-based sound models for interaction were developed and implemented as pure data external objects. Those results were extensively revised, and expanded through development and implementation of a new waveguide resonator model (simulating an ideally elastic string, controllable by physical-geometric parameters). This work will be exploited by the EU project CLOSED, for which a re-engineering and further expansion of the package will be carried out.

1.5 Auditory distance perception in the acoustic pipe

In a study of auditory distance perception, the authors investigated the effects of exaggerating the acoustic cues of reverberation in stimuli, where the intensity of sound did not vary noticeably. The set of stimuli were obtained by moving a sound source inside a $10.2m$ long pipe having a $0.3m$ round section. In a training-free magnitude production experimental design procedure, subjects were asked to listen to a speech sound, while keeping their head inside the pipe, then to estimate the egocentric distance from the sound source. The procedure was repeated several times using six different positions of the sound source. Results show that the point at which perceived distance equals physical distance is approximately located $4m$ away the listening point, meanwhile the pipe renders distances across an average range of about $3.5m$, i.e. from $1.9m$ to $5.4m$. The absence of intensity cues makes the acoustic pipe a potentially interesting modelling paradigm for the design of auditory interfaces in which distance is rendered independently of loudness. On the other hand, the proposed acoustic environment does not overcome the known unreliability of auditory distance cues.

1.6 On the use of Kernel-based methods in sound synthesis by physical modeling

This paper presents an approach to the modeling of acoustic systems that combines prior information, exploited through physical modeling, and nonlinear dynamics reconstruction, exploited through support vector machine regression. We demonstrate our approach on two case studies, both addressing the broad class of acoustic systems for which the sound generation is obtained through the interaction of a linear system (resonator) and a nonlinear system (excitation). The first case is a physically based impact model, where the resonator is described in terms of its normal modes and the nonlinear contact force is modeled through a simplified collision equation and kernel regression. In the second case study, a model of the voice phonation is illustrated in which the vocal folds are represented by a lumped linear mass-spring system and the nonlinear flow component is modeled through simple Bernoulli-based equations and kernel regression.

2 Indirectly Related Publications

Besides these publications directly related to the topics studied within the CLOSED framework, some side questions have also lead to publications.

First, informative auditory cues span over all sonic attributes. Hence, sounds that convey sense of depth can find convenient place within interaction design patterns including depth as a dimension that must be exposed to the user's experience. Again in this sense, results in audio-visual interactions cannot but increase the designer's confidence in cogitating effective multimodal interaction paradigms. This issue has been therefore adressed by the paper submitted by Devallez et a. to ICAD 2007 (see section 2.1).

Secondly, increasing the knowledge in digital filter structures enabling physics-based sound modelling, such as the Moog VCF digital filter (proposed in section 2.2) does, has the benefit to fill the gap between the design and engineering activity by proposing processing tools that are much more friendly to instantiation with designs, which are closer to the physical reality.

2.1 An experimental evaluation of the influence of auditory cues on perceived visual orders in depth

To increase the realism of sounds created by physical models as well as to improve their interactions with each other and with the user, it is proposed to add an extra spatialization layer, which is able to render in real-time the spatial relative positions of the sounding objects. In particular, distance rendering is considered to create perspective effects. For use in audio-visual interfaces, perspective effects may be created both visually and auditorily, which may lead to cross-modal interactions.

In this article, the authors present an experiment investigating the influence of auditory cues on visual perceived orders in depth. Visual stimuli consisted in a layered 2D drawing of two squares respectively blue and red using semi-transparency. Auditory signals of the two words "red" and "blue" were presented simultaneously to the images. Subjects were required to determine which square appeared in front of the order in these cross-modal conditions. The coefficient of transparency as well as the audio level difference between the two speech signals "red" and "blue" were systematically varied. No significant influence of auditory cues on perceived order in depth was found, except when the visual information was totally ambiguous: In this case, the perceived order showed limited dependence on the acoustic information.

2.2 Preserving the Structure of the Moog VCF in the Digital Domain

In this article, the author proposes a novel discrete-time model of the Moog VCF based on the explicit computation of the delay-free loop contained in that filter. Compared to the previous documented solutions, the model presented in this article shows accurate frequency responses, when working in normal conditions, meanwhile preserving good numerical stability, and direct access to the parameters of cut-off frequency and feedback gain. These features make the proposed model a candidate for efficient implementation on fixed-point architectures as well as in normal PC's, in the form of software plug-in. The structural correspondence with the Moog VCF allows to transpose peculiar behaviours of the analogue system directly in the discrete-time model.

Conclusion

In the recent period, the CLOSED project published two articles in the proceedings of the conferences PQS 06 and ICMI 06, and submitted eight more articles to the conferences ICAD 07, ICMC 07, NIME 07, and CIM 07. The partners of the CLOSED project submitted two journal papers as well, namely to ACM Transactions on Applied Perception, and to Numerical Algorithms. In order to give an idea about the contents of these papers, some of these articles are briefly summarised based on their abstracts in the previous sections of this report. For the rest of the articles or for the whole content of them please refer to the bibliography section.

The consortium plans to continue submitting articles about the obtained results in the following period. They will be reported in the following deliverable period, which is at the end of the 23. month.

References

[1] P. Susini, N. Misdariis, G. Lemaitre, O. Houix, D. Rocchesso, P. Polotti, K. Franinovic, Y. Visell, K. Obermayer, H. Purwins, K. Adiloglu: Closing the Loop of Sound Evaluation and Design, Proceedings of the Perceptual Quality Systems, Berlin, Germany, 2006.

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