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NOVEL INTERFACES FOR CONTROLLING SOUND EFFECTS AND PHYSICAL MODELS

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ABSTRACT

In this paper we introduce four different novel interfaces for musical expression designed at the Medialogy department at Aalborg University in Copenhagen. The common goal of such interfaces is the desire to create novel musical instruments which look aesthetically pleasing, are easy to learn how to play and produce interesting sound effects and synthetic sounds. The design of the different instruments is described, together with their use to control real-time sound synthesis algorithms.

1. INTRODUCTION

Real-time gestural control of computer generated sounds has become in the past years a common trend in the computer music community. A conference dedicated to this topic, called NIME (which stands for New Interfaces for Musical Expression) has been created in 2001, and several new input devices have been designed [1, 2].

Such devices can be classified as 1) instrument-like controllers, which try to emulate the control interfaces of existing acoustical instruments; 2) instrument-inspired controllers, which follow characteristics of existing instruments; 3) extended instruments, i.e., acoustical instruments augmented with sensors and 4) alternate controllers, whose design does not follow any traditional musical instrument [3].

In this paper we present different novel interfaces for sound effects and physical models developed in the Medialogy department at Aalborg University in Copenhagen. Three interfaces are alternate controllers, since their design does not follow any traditional musical instrument. The Croaker, on the other end, is an instrument-inspired controller, since it is inspired by Russolo's Intonarumori instruments [4].

All the interfaces use a microcontroller developed by MakingThings[1] and Max/MSP[2] for the implementation of sound effects and sound synthesis algorithms.

2. CONTROLLING AUDIO

Controlling auDio (ConDio), shown in Figure 1, is a real time interactive sound effect mixer that controls different audio samples by combining, amplifying and modulating the sound properties in relation to the users needs.

The ConDio interface is inspired by the Audiopad [5] and the more recent Reactable* [6]. The ConDio manipulates sounds with the use of different digital filters and sound effects in order to provide versatility and adaptability of the sample characteristics. The ConDio is a tangible interface which makes use of plastic objects such as cylinders and squares to represent different musical functions. Each object represents a different sound sample, a sound effect, a filter or a function; each object is able to interact with another by measuring the distance between the two objects.

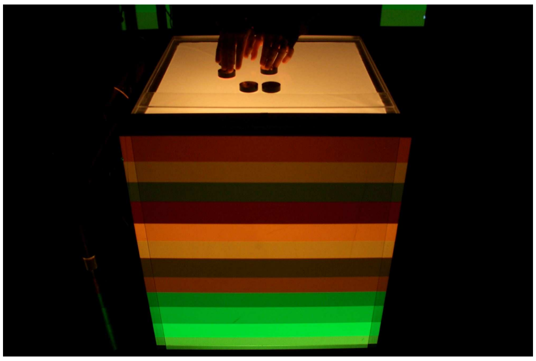

Figure 1: *The ConDio*

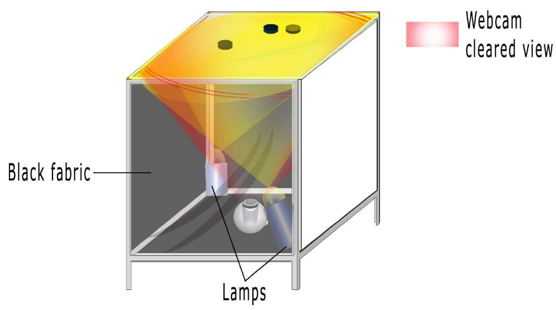

Figure 2: *The ConDio setup.*

A schematic representation of the ConDio is shown in Figure 2. A webcamera is placed inside the box, to track objects on top of the box. Two lamps are also placed in the box, to facilitate

[1] www.makingthings.com
[2] www.cycling74.com

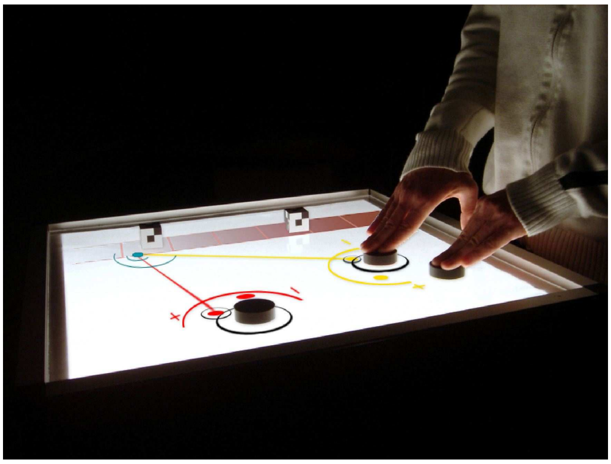

Figure 3: *The ConDio interface.*

tracking of the objects which is performed using computer vision. To further facilitate the tracking, a black fabric covers the sides of the box.

2.1. Sound effects

The main goal of the ConDio is to manipulate and control different sound effects by moving several objects on top of the table which are tracked using computer vision techniques.

The different sound effects and computer vision tracking were designed under the Max/MSP and Jitter platforms respectively. Different effects such as delay, flanger, filtering, wah-wah effect [7] were implemented. The interface allows the user to select among different sound samples by triggering them using the finger. The different sound manipulation techniques are controlled by pucks of different colors.

The ConDio is an interface which is fun to play and aesthetically pleasing. As can be seen in Figure 1, an abstract representation of a sonogram is also projected in the front side of the instrument, to complement the auditory experience with a pleasing visual experience.

With the ConDio it is possible to control sound effects, but the user cannot create his or her own sound samples by using, for example, sound synthesis techniques. This is made possible by using the interface described in the following section, called CreDio (which stands for Creating Audio).

The CreDio can be used as a sound interface on its own, or it can also be used as an input connected to the ConDio interface.

3. CREATING AUDIO

Creating Audio (CreDio), shown in Figure 4, is a novel musical instrument that combines digital and mechanical functions to control sound synthesis algorithms.

The instrument includes a LCD display (A, Figure 5), a circle composed of a set of three rings which can spin on their own axis and interact with a infinitely rotating potentiometer (B, Figure 5), six pressure sensitive locations (C, Figure 5), five buttons placed in the shape of a plus sign for menu navigation (D, Figure 5), and a microphone (E, Figure 5).

The different components of the instrument have been carefully crafted, because of their mechanical complexity. In particular, the rings inside the instrument needed to be able to fit and rotate inside each others.

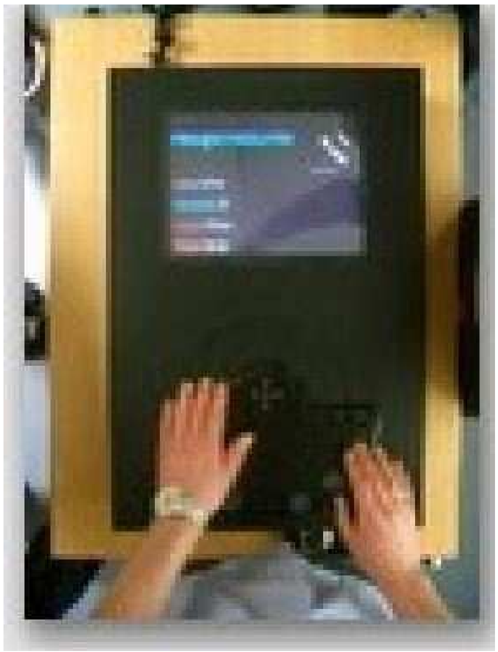

Figure 4: *The Creating Audio (Credio) interface.*

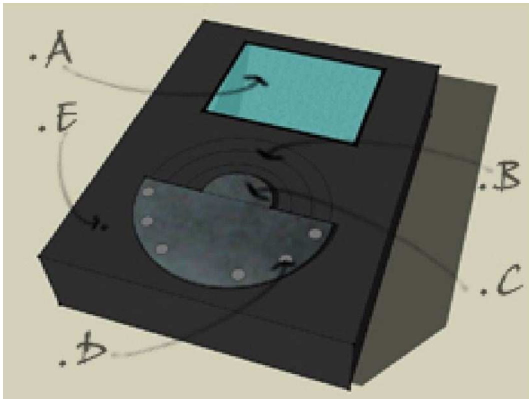

Figure 5: *The Credio interface with an LCD display (A), three spinning rings (B), six pressure sensitive locations (C), five buttons (D) and a microphone (E).*

As shown in Figure 6, a track was carved into any bottom side of the rings, followed by a track carved on the bottom plate. Such tracks hold a series of metal balls, which allow to stabilize the rings in place and to give each individual ring the ability to spin independently from each other and in any direction.

The rotation of the rings is detected by potentiometers attached as shown in Figure 7.

On top of the rings, a drumpad is built. The bottom part of the drumpad contains six force sensitive resistors, as shown in Figure

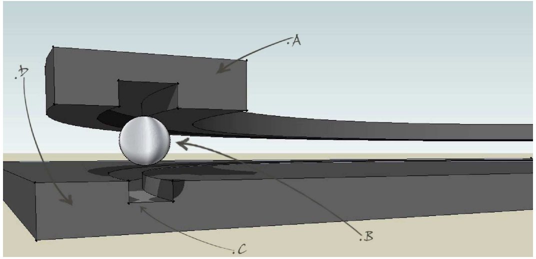

Figure 6: *A track carved inside the rings allows the rings to rotate indipendently and in any direction.*

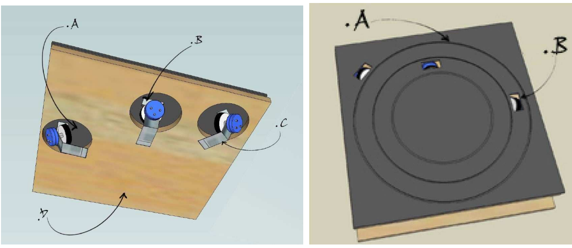

Figure 7: *Potentiometers attached to the rings allow to detect their rotation.*

8, part D. The drumpad was built of different layers: a stiff surface (part D), with a soft surface on top (part B) and black latex covering the surface (part E).

A voltage divider circuit with the menu navigation buttons was placed inside the circle, as shown in Figure 10 (left). The pad was then marked on the latex surface where the pressure sensors where situated. The area that covered the voltage divider circuit with the five menu navigation buttons was also clearly marked. The buttons where placed and marked in the shape of a plus sign in order to provide an intuitive form for menu navigation, as shown in Figure 10 (right).

The last sensing device implemented was a microphone placed under the bottom left side of the box.

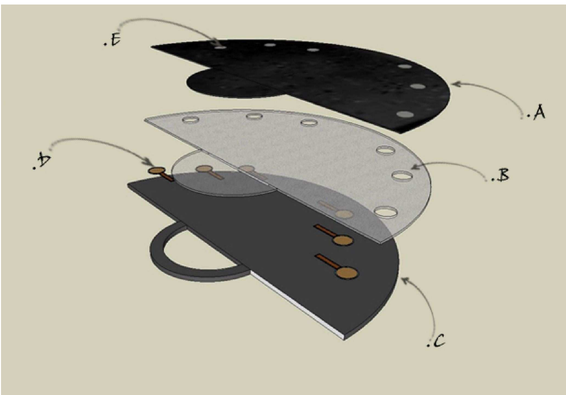

Figure 8: *Structure of the drumpad which contains six force sensitive resistors.*

Figure 9: *Attaching the drumpad to the interface.*

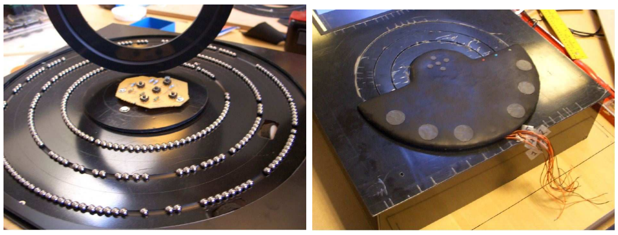

Figure 10: *The wheel designed for menu navigation in the Credio interface.*

3.1. Sound synthesis

Different traditional sound synthesis algorithms were implemented in Max/MSP, such as frequency modulation [8] and granular synthesis [9].

The five buttons were used to move from one sound synthesis algorithm to another.

The rotation of the rings controlled the different parameters of the FM and granular synthesis algorithm. The pressure sensors controlled the amplitude of the sound produced.

To allow the user to keep track of the actions produced, a graphical user interface was also implemented using Macromedia Flash[3] and the Flashserver connection between Max/MSP and Flash [4].

The design of the Credio presented different challenges, especially from the mechanical point of view. Lots of efforts was put by the designers in order to carefully craft all the different components of the instrument.

In the following section we describe an interface which is inspired by existing musical instruments, i.e., the Intonarumori by Luigi Russolo.

4. THE CROAKER

At the beginning of the 20th century, the Italian composer and painter Luigi Russolo designed and built a family of new musical instruments which he called Intonarumori (noise intoners). Each Intonarumori was made of a parallelepipedal sound box with

[3] http://www.adobe.com/
[4] http://www.nullmedium.de/dev/flashserver/

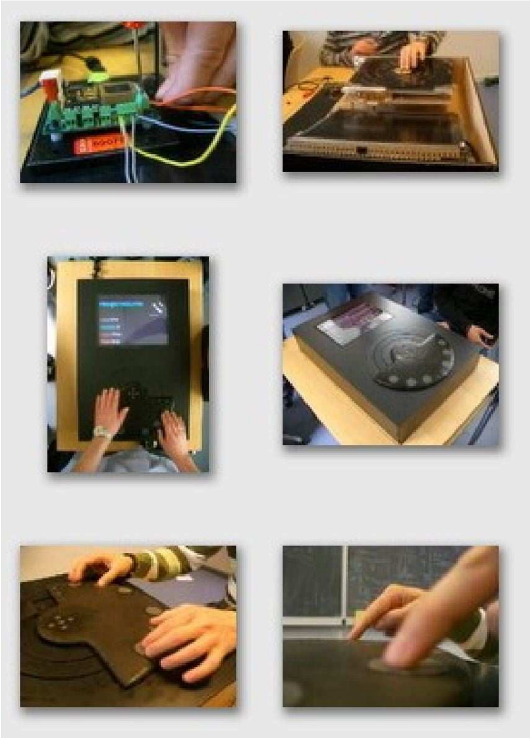

Figure 11: *The Credio controller*

a speaker on its front. Inside the box, a gut or metal string was excited by a rotating wheel. The speed of the wheel was changed by the player by using a crank, while the tension of the string was varied by using a lever. Such instruments were acoustic noise generators which allowed to simulate different everyday noisy sonorities. In the attempt to create a modern reconstruction of Russolo's Intonarumori, which could be used both as a musical instrument on its own and as an interface for real-time sound synthesis, we designed the Croaker, shown in Figure 12.

The Croaker can be classified as an instrument-like controller [3], since it emulates the control interface of an existing, although not popular, acoustical instrument.

The current prototype of the Croaker is shown in Figure 12. As in the original Intonarumori, the Croaker is provided with a one degree of freedom lever, and a rotating crank. The position of the lever is detected by a potentiometer, while the rotation of the crank is also sensed by a second potentiometer.

The Croaker is an interface which is easy to learn how to play. It is played by controlling the position of the lever with the left hand, while rotating the crank with the right hand.

4.1. Sound synthesis

The Croaker is a controller which can drive several sound synthesis algorithms. In developing the sound synthesis engine, we followed the approach of decomposing a vibrating system into exciter and resonator [10].

In particular, we simulated the vibrating string positioned inside the instruments as a modal resonator [11, 12]. The parameters of the string are controlled directly in the software engine.

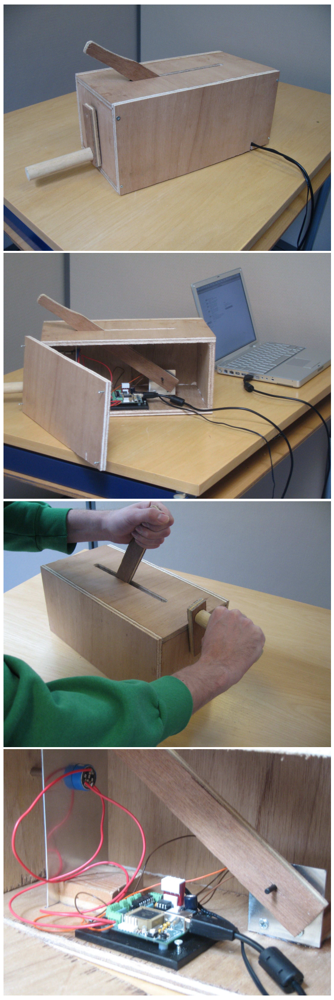

Figure 12: *The Croaker. From top to bottom: a view of the instrument, a view of the microcontroller and the sensors inside the instrument, use of the instrument and a close view of how the sensors are connected to the lever and crank.*

The string is excited by different mechanisms, which allow to create different everyday sonorities. We are interested in simulating scraping and screeching sounds, as well as percussive sounds, rumbling, roars and voices. It is interesting to notice that by simply varying the excitation mechanism and the resonant frequencies of the resonator it is possible to simulate different kinds of everyday sounds, from scraping to laughing sounds.

To model the sustained excitation between the rotating wheel and the string, the elasto-plastic friction model proposed in [13], and already adopted for sound synthesis purposes in [14], is used. In this model, the interaction between the string and the rotating wheel is described by using a differential equation. A detailed description of the use of this model for real-time sound synthesis is proposed in [15].

Rumbles, roars and percussive sounds were obtained using the physically informed sonic model (PhiSM) algorithm proposed by Perry Cook [16]. This algorithm has proved to be suitable for the synthesis of everyday percussive sounds. In this situation, the lever controls the fundamental frequency of the particles, while the lever controls the probability of contact among particles.

In the Art of Noise, [4], Russolo describes the sound produced by the Bursters instruments, claiming that such instruments produced two kinds of sonorities. The first resembles the sound of a motor, while the second reminded the sound of breaking objects. To simulate breaking sonorities, we adopt the algorithm suggested in [17]. In this algorithm, the fundamental frequency of the resonators increases over time, to simulate the size reduction of the broken object. Moreover the breaking sound is simulated by having impact events increasing over time.

By choosing the appropriate modal frequencies of the resonator, it is possible to simulate simple laughing sonorities. In particular, we used the time domain formant wave function synthesis (FOF) technique [18], to generate different vowels by combining particles together, each representing a fundamental period of a signal corresponding to a formant. Notice that PhiSM can be seen as a generalization of FOF, as described in [19].

In the following section we describe a generalized controller for physical models, called the Physmism.

5. PHYSMISM

Figure 13: *The Physmism interface.*

The Physmism, shown in Figure 13, is an interface designed to create a generalized controller for physical models. The instrument controls different algorithms reproducing several excitation mechanisms such as sustained excitation, transient and percussive excitation and blowing excitation.

The interface preserves the look of old analogue synthesizers. A simple push button allows to switch between different resonators. Four potentiometers, placed on top of the instrument, allow to alter the resonator's characteristics of the physical models.

The blowing excitation mechanisms is controlled by using a flute controller shown in Figure 14. This device was already used in [20] to produce a virtual reality flute. The blowing excitation is implemented by using a fan attached to a dynamo. The three push buttons on the top of the instrument are used to change the fundamental frequency of the note produced.

A sustained excitation mechanism is controlled by using a slider placed on top of the instrument.

A percussive excitation was also implemented, by using three rubber bubbles containing in the inside small condenser microphones. By using a peak detector circuit, it is possible to obtain a signal whose amplitude can be tracked in real-time.

Figure 14: *The flute controller used together with the Physmism interface.*

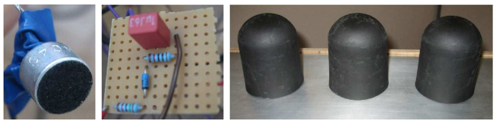

Figure 15: *The percussive excitation mechanism on top of the Physmism (right), and the microphone placed inside the rubber bubbles (left).*

Furthermore a plucking excitation mechanism was implemented, by using infrared light detection as shown in Figure 16. This sensor works only within a range of about 10-12 cm, which can be helpful since it avoids the creation of a sudden excitation when people pass by. One drawback of this sensor is the lack of tactile feedback, which is an important component of a finger exciting a string.

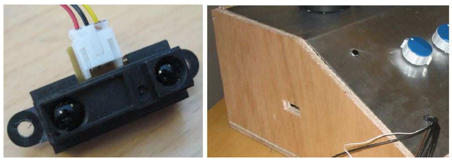

Figure 16: *The infrared sensors attached on the side of the instrument.*

A crank was also attached to the instrument, as shown in Figure 17. The crank allows the control of the physically inspired sonic model algorithm (PHISM) developed by Perry Cook [16].

As an additional excitation mechanism, a microphone is attached in front of the controller, to allow the voice to be used as an input to the resonator of the physical model.

5.1. Sound synthesis

The percussive excitation and the rotating excitation given by the crank are used to control a modal synthesizer [11, 12] and a PHISM synthesizer [16] respectively.

The flute controller is used to drive a waveguide flute physical model, similar to the one described in [21]. The friction model used is the one described in [15].

The percussive excitation controls a physical model of a drum implemented as a two-dimensional waveguide mesh [22].

The complexity of the different physical models and the high number of input parameters provides different advantages from the flexibility point of view, but also some disadvantages for the complexity of the control. To help the user, a visual feedback was developed, which provided information concerning which physical model was current in use and which parameters were modified. The visual feedback is shown in Figure 18.

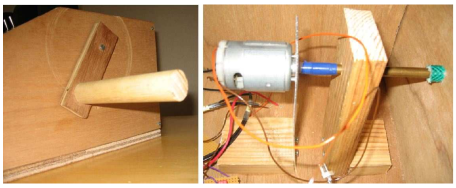

Figure 17: *The rotating crank attached on the side of the instrument.*

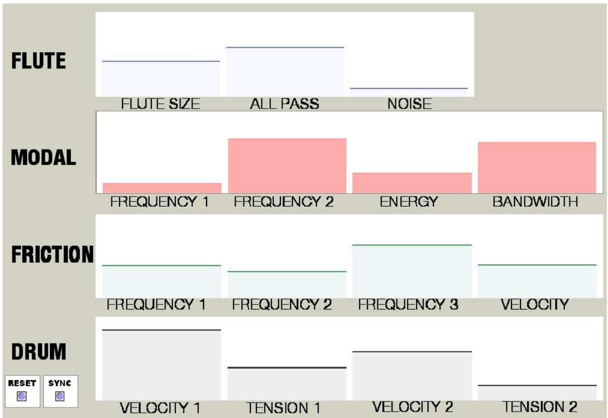

Figure 18: *Visual feedback for the Physmism allowing the user to keep track of the sound synthesis algorithm used.*

6. CONCLUSION

In this paper we described four different interfaces used to control several sound effects and sound synthesis algorithm. The Condio interface was developed during the Fall semester 2005 as a final project by six students enrolled in their first semester of the Medialogy bachelor education. The Credio interface was developed by the same students as a final project for their second semester project during the Spring semester 2006.

The Physmism was developed by two students enrolled in the third semester of the Master education during the Spring semester 2006. The Croaker was also built during the Spring 2006.

7. REFERENCES

[1] M. Wanderley, *Trends in Gestural Control of Music.*, Ircam. Centre George Pompidou., 2000.

[2] P. Cook, "Principles for designing computer music controllers.," in *Proc. CHI*, 2001.

[3] M. Wanderley, N., and Orio, "Evaluation of input devices for musical expression: Borrowing tools from hci.," *Computer Music Journal*, vol. 26, no. 3, 2003.

[4] L. Russolo, *L'arte dei rumori (The art of noises)*, Edizioni Futuriste di Poesia, 1916.

[5] B. Recht J. Patten and H. Ishii, "Audiopad: a tag-based interface for musical performance.," in *Proc. NIME*, 2002.

[6] S. Jorda', "Sonigraphical instruments: from fmol to the reactable*.," in *Proc. NIME*, 2003.

[7] U. Zolder (editor), *Digital audio effects*, John Wiley Sons, 2002.

[8] J. Chowning, "The synthesis of complex audio spectra by means of frequency modulation.," *Journal of the Audio Engineering Society*, vol. 21, no. 7, 1973.

[9] C. Roads, *The computer music tutorial.*, MIT press, 1996.

[10] G. De Poli G. Borin and A. Sarti, "Sound synthesis by dynamic systems interaction," *Readings in Computer-Generated Music. IEEE Comp. Soc. Press*, 1992.

[11] J.M. Adrien, *The Missing Link: Modal Synthesis*, Representation of Musical Signal, G.. De Poli, A. Picialli, and C. Roads, eds, Cambridge, Massachusetts, MIT Press.

[12] D. Rocchesso and editors. F. Fontana, *The Sounding Object.*, Mondo Estremo, Firenze, Italy, 2003.

[13] B. Armstrong P. Dupont, V. Hayward and F. Altpeter, "Single state elasto-plastic friction models," *IEEE Transactions on Automatic Control*, vol. 47, no. 5, 2002.

[14] F. Avanzini, S. Serafin, and D. Rocchesso, "Modeling interactions between rubbed dry surfaces using an elasto-plastic friction model.," in *Proc. DAFX*, 2002.

[15] F. Avanzini, S. Serafin, and D. Rocchesso, "Interactive simulation of rigid body interaction with friction-induced sound generation," *IEEE Transactions on Speech and Audio Processing*, vol. 13, no. 5, 2005.

[16] P. R. Cook, "Physically informed sonic modeling (phism): Synthesis of percussive sounds.," *Computer Music Journal*, vol. 21, no. 3, 1997.

[17] W. Gaver, "Synthesizing auditory icons.," in *INTERCHI*, 1993.

[18] X. Rodet, "Time-domain formant wave-function synthesis.," *Computer Music Journal*, vol. 8, no. 3, 1984.

[19] P. Cook, *Real sound synthesis for interactive applications.*, AK Peters., 2002.

[20] L. Martinussen N. Böttcher, S. Gelineck and S. Serafin, "Virtual reality instruments capable of changing dimensions in real-time.," in *Proc. Enactive*, 2005.

[21] R. Hänninen and V. Välimäki, "An improved digital waveguide model of a flute with fractional delay filters.," in *Proc NAM*, 1996.

[22] S. Van Duyne and J. Smith, "Physical modeling with the 2d waveguide mesh.," in *Proc. ICMC*, 1993.