Synthesis and control of everyday sounds reconstructing Russolo's Intonarumori

Serafin, Stefania; Gelineck, Steven

Published in:
New Interfaces for Musical Expression

Publication date:
2006

Document Version
Publisher's PDF, also known as Version of record

Synthesis and control of everyday sounds reconstructing Russolo's Intonarumori

Stefania Serafin
Medialogy
Aalborg University
Copenhagen
Lautrupvang 15, 2750
Ballerup, DK
sts@media.aau.dk

Amalia de Götzen
Dep. of Information
Engineering
DEI/CSC,
Padova, Italy
degotzen@sci.univr.it

Niels Böttcher,
Steven Gelineck
Medialogy
Aalborg University
Copenhagen
Lautrupvang 15, 2750
Ballerup, DK
nboe05@imi.aau.dk

ABSTRACT

In this paper we introduce the Croaker, a novel input device inspired by Russolo's Intonarumori. We describe the components of the controller and the sound synthesis engine which allows to reproduce several everyday sounds.

Keywords

Noise machines, everyday sounds, physical models.

1. INTRODUCTION

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 colorful parallelepipedal sound box with 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.

The Intonarumori were a consequence of Russolo' s theories regarding the structure of the Futuristic orchestra. With the belief that the traditional orchestra needed some new sonorites, in his Futuristic manifesto *The Art of Noises* [12], Russolo proposed a taxonomy of noisy sounds divided in six families, organized as shown in Table 1. The different instruments designed by Russolo were a consequence of his Futuristic ideas. As can be seen in Table 1, the instruments were named according to the kind of sonorities they were able to produce.

Russolo's ideas were certainly very innovative: the composer was trying to design new interfaces for musical expression, to cope with the limitations of the traditional orchestra. Unfortunately, his ideas were probably too progressive for his time, so during his concerts the audience was merely laughing at his instruments rather than trying to understand the novelties introduced.

Moreover, during World War II all the original Intonarumori got destroyed. Since then, several attempts to rebuild such instruments were made. Among them, the ones shown in Figure 1 are some reproductions displayed at the exposition Sounds and Lights at the Pompidou Center in Paris in December 2004.

In this paper, we are interested in designing a controller and sound synthesis engine able to reproduce the different instruments designed by Russolo.

2. RUSSOLO'S INTONARUMORI

Figure 1: Different Intonarumori as shown in the exposition Sounds and Lights, Paris, Pompidou Center, December 2004.

Figure 2 shows Luigi Russolo and his colleague Ugo Piatti playing the original Intonarumori at around 1913.

As can be seen in Figure 2, each Intonarumori was made of a parallelepipedal box, with a crank and a lever in the outside. The player, by rotating the crank, was able to rotate a wheel placed inside the box, which excited a vibrating string. The string, stretched at the two extremities of the box, was attached to a vibrating drum connected to a radiating horn. By moving the lever back and forth, it was

Family 1	Family 2	Family 3	Family 4	Family 5	Family 6
Rumbles roars explosions crashes splashes booms	Whistles hisses snorts	Whispers murmers mumbles grumbles gurgles	Screeches creaks rustles buzzes crackles scrapes	Noises made by percussion on metal wood skin	Voices of animal and man shouts,screams, groans,shrieks, howls,wheezes and sobs.
Roarer Burster	Whistler Hisser	Gurgler	Croaker Crackler	Rubber	Hummer Howler

Table 1: Different families of noises as described by Russolo in [12]. The top part of the Table lists the different families, while the bottom part shows the corresponding musical instruments designed by Russolo.

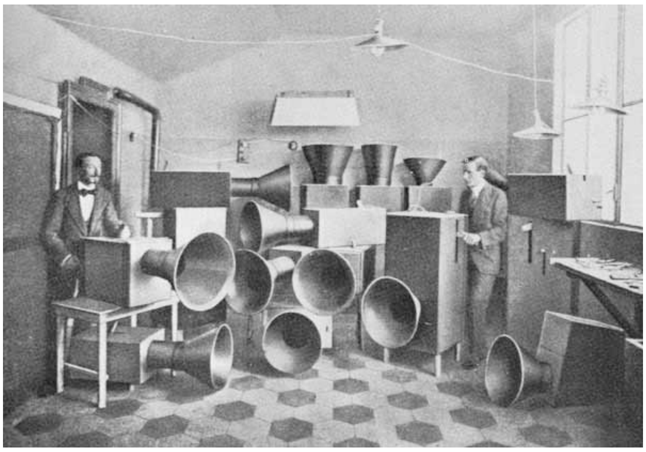

Figure 2: Russolo and his colleague Ugo Piatti playing the original Intonarumori. From [8].

possible to change the tension and length of the vibrating string, and therefore its fundamental frequency.

The 27 varieties of Intonarumori built by Russolo and his colleagues aimed at reproducing different varieties of noises. The names of the instruments were assigned according to the sound they produced. As an example, in the *Gracidatore* (the Croaker), whose excitation mechanism is shown in Figure 3, the shape of the rotating wheel allows to obtain plucked string sonorities. The wheel, rotating at a speed controlled by an external crank, excites a vibrating string attached at two extremities of the wooden soundbox. The player, as in the other instruments, is able to control the tension of the string by using an external lever.

In the Crepitatore (the Cracker), shown in Figure 4, the excitation mechanism is a metal wheel, and two levers are present, as well as two vibrating strings. This allowed the string attached to the drumskin to be different from the one excited by the rotating wheel. The same idea was also adopted in the Stroppicciatore (the Rubber). A second lever was also added to the Burster (Scoppiatore), the Whistler (Sibilatore) and the Gurgler (Gorgogliatore). In his writings, Russolo does not explain the need for such second lever. Moreover, documents and patents did not succeed in explaining the role of the two strings in the resulting sonorities produced by the instruments [8].

In the Ululatore (Howler), described by Russolo as *soft, velvety and delicate* and the most musical among the instruments [12], shown in Figure 5, the excitation mechanism was a smooth wooden wheel. Russolo underlines the fact that this instrument could produce very long notes, since the duration of the notes depended by how long the performer turned the crank.

Russolo and his assistant Ugo Piatti researched all the physical aspects that could be varied to obtain different timbres and sonorities, in order to achieve a satisfactory simulation of the families of noises described above.

As an example, the string was made of either steel or gut, the wheel was made of metal or wood, with its rim notched with small teeth or smoother, and the skins were soaked in a variety of special chemical preparations. Furthermore, the pressure of the wheel against the string, stronger than is necessary with a violin bow, created a louder and noisier sound quality.

Russolo also experimented with more radical Intonarumori, based on electrical rather than mechanical control, such as the one used in the Hummer (Ronzatore), which was more a percussion than a string instrument. It has been suggested that the electrical control might have been due to the need for a speed that was too rapid to have been achieved manually.

3. THE CROAKER

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 6.

The Croaker can be classified as an instrument-like controller [13], since it emulates the control interface of an existing, although not popular, acoustical instrument.

The first prototype of the Croaker, shown in Figure 6, is an interface built with Lego blocks. The name of the instrument derives from one of the original Russolo's instruments.

As in the original Intonarumori, the Croaker is provided with a one degree of freedom lever moving vertically, and a rotating crank. The position of the lever is detected by a potentiometer, attached as shown in the right side of Figure 6. The rotation of the crank is also sensed by a second potentiometer, attached to the wheel as shown in Figure 6.

The second prototype of the Croaker is shown in Figure 7.

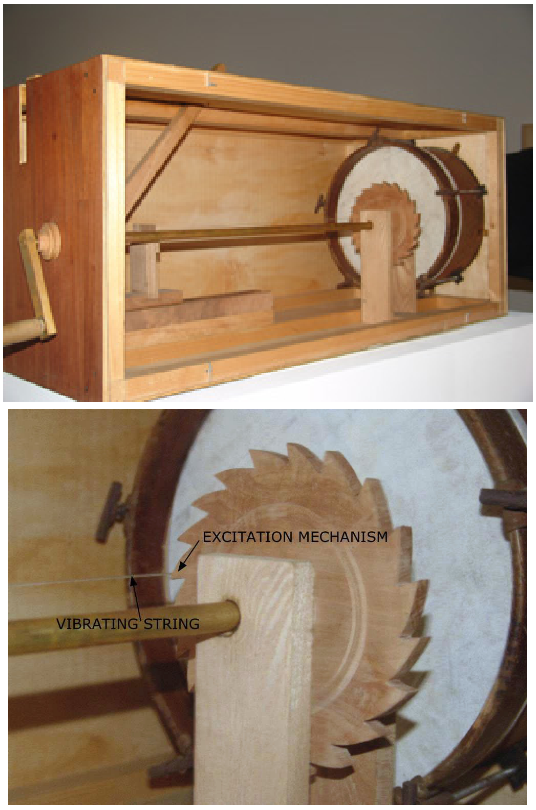

Figure 3: A view of the Gracidatore (top), and its excitation mechanism (center).

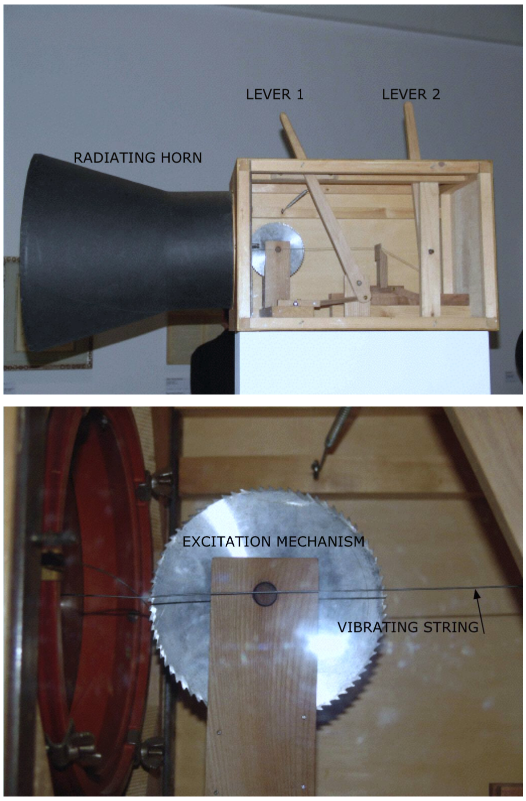

Figure 4: Reproduction of the Crepitatore (top). In this instrument, two levers are present. Bottom: the excitation mechanism of the Crepitatore.

Compared to the one shown in Figure 6, the instrument has a more compact shape, and a linear slider is provided. Such slider allows to vary the frequency range of the instrument.

The current prototype of the Croaker is shown in Figure 8. As the original instruments, the Croaker is now made of wood. The more robust design allows the instrument to be used in performances.

In all prototypes, the sensors are attached to a Teleo microprocessor manifactured by Making Things.[1] The microprocessor is connected to a computer through the USB port. In the current prototype, the microprocessor is placed inside the Lego box.

By using the Max/MSP and Jitter software,[2] some adhoc external objects have been developed by MakingThings, which convert the sensors data into numerical input which can be read by Max. Such data are used as controllers to different sound synthesis engines, as described in the following section.

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. It is also possible to vary the frequency range of the instrument by using the linear slider.

4. THE SOUND SYNTHESIS ENGINE

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 [6].

In particular, we simulated the vibrating string positioned inside the instruments as a modal resonator [1, 10]. The parameters of the string are controlled directly in the software engine, as described later. 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

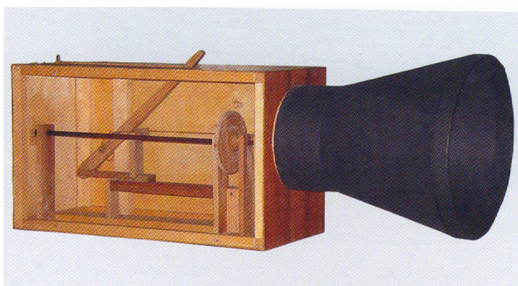

Figure 5: Reproduction of the Ululatore.

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

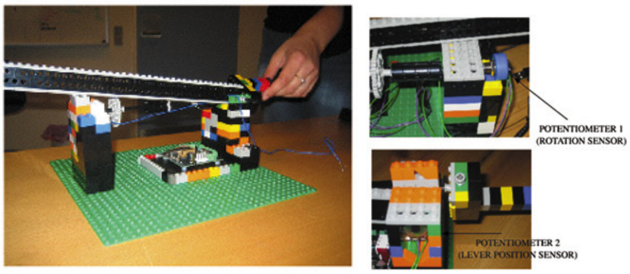

Figure 6: The first prototype of the Croaker (left). Placement of the two potentiometers in the Croaker. The first potentiometer detects the position of the lever, while the second detects the position of the crank (right).

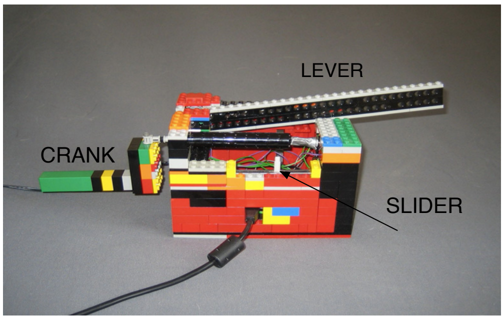

Figure 7: The second prototype of the Croaker.

sounds, from scraping to laughing sounds.

4.1 Scrapes and screeches

Instruments such as the Howler are characterized by a smooth rotating wheel, which continuously interact with the vibrating string. To model the sustained excitation between the rotating wheel and the string, the elasto-plastic friction model proposed in [9], and already adopted for sound synthesis purposes in [2], 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 [3].

4.2 Rumbles, roars and percussive sounds

Rumbles, roars and percussive sounds were obtained using the physically informed sonic model (PhiSM) algorithm proposed by Perry Cook [5]. 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.

4.3 Breaking sounds

In his documents, Russolo described 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 [7]. 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.

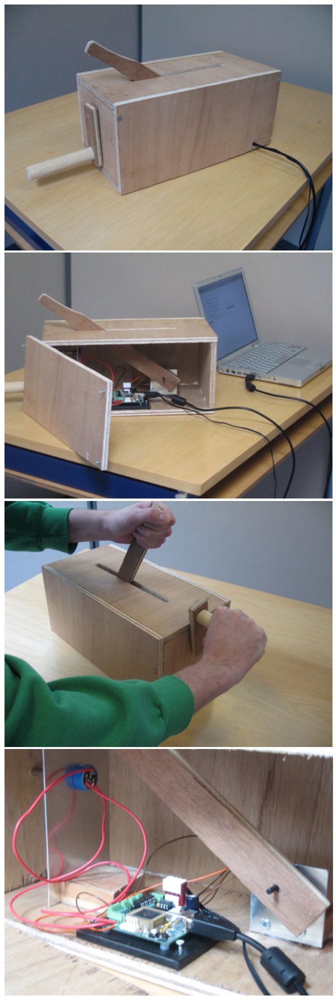

Figure 8: The current prototype of the Croaker. From top to bottom: a view of the instrument, a view of the microcontroller and the sensors inside the instrument, use of the instrument and a close view of how the sensors are connected to the lever and crank.

4.4 Laughing sounds

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 [11], 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 [4].

5. MAPPING

Figure 9 shows the connection between the control parameters of the instrument and the sound synthesis engine. As described before, the player is able to control two param-

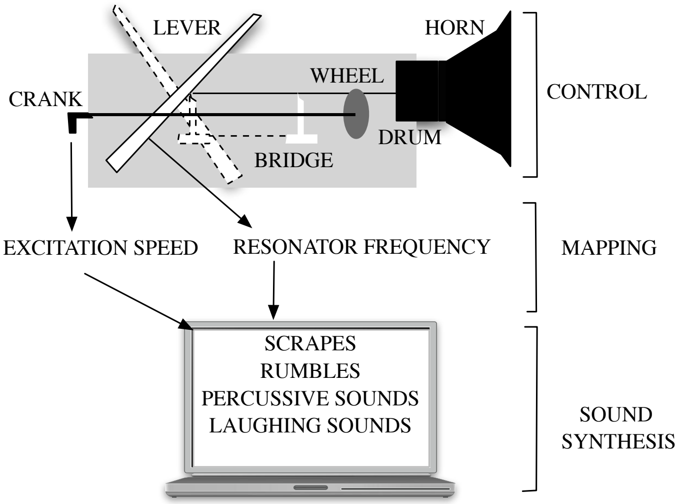

Figure 9: Mapping between the control parameters of the Croaker and the sound synthesis engine.

eters: excitation velocity, which is given by the rotational speed of the rotating crank, and position of the lever. Additionally, a slider allows to change the frequency range of the sound synthesis engine. The mapping strategy chosen reflects the design by Russolo. Infact, the rotating crank controls the speed of the rotating wheel inside the instrument, i.e., the speed of the excitation mechanism.

The lever, on the other end controls the fundamental frequency of the resonator.

This mapping is both intuitive from the player's perspective and faithful to the initial design by Russolo.

6. IMPLEMENTATION

The Intonarumori model has been implemented as an extension to the Max/MSP environment. In the Intonarumori originally designed by Russolo, the control parameters of the instruments are the type of excitation mechanism (plucked or rubbed), which corresponds to the simulation of different instruments of the family, the rotational velocity of the excitation wheel, controlled by the player through the external crank, and the string tension, controlled by the player by moving the lever on top of the instrument. Additionally, it is possible to control the frequency range of the vibrating string by using a continuous linear slider. Figure 10 shows the Max/MSP patch which simulates the Intonarumori described in the previous section. In this patch, it is possible to identify three main components. The top part contains the objects which implement the connection between the Teleo sensors board and Max/MSP. These objects are already available from the Making Things website (www.makingthings.com). The central part contains the mapping strategies to connect the data of the sensors to the sound synthesis engine. The position of the lever is mapped linearly to the fundamental frequency of the string. The fundamental frequency of the string can also be varied by using the linear slider. The rotational velocity of the crank is obtained by calculating the derivative of the position, and is mapped to the excitation velocity of the sound synthesis model. In the case of a transient excitation, the excitation velocity affects the number of bumps per second. In the case of the sustained excitation, the velocity affects the exciter velocity. As is the case in the original instruments, the excitation force cannot be controlled by the player, but it is predefined in the physical model. Similarly, the parameters of the friction model, as well as the different strings' material need to be chosen in the Max/MSP patch, and cannot be chosen using the controller.

In the original Intonarumori, all the instruments had the same control mechanism, and sonorities could be varied by changing the instruments. The same happens in our case: we have a single controller able to drive all the instruments, but in order to change from one instrument family to another it is currently necessary to select a different option in the Max/MSP engine.

7. CONCLUSION

In this paper we introduced the Croaker, a new input interface inspired by Luigi Russolos Intonarumori. Experiments with the instrument show that users find it easy to learn how to play and at the same time entertaining. We found that users quickly adjusted to the mapping strategies and control parameters of the instrument, given the limited amount of control possibilities. This of course can represent both an advantage and a limitation of the instruments. If the instruments had to be used in a performance, it would be helpful to have several of them, as Russolo was doing in his concerts. This could allow novice performers to get involved in new music.

Currently, the sound synthesis engine is imitating the sonorities produced by Russolo's original instruments. Sound synthesis could of course also be used to extend sonic possibilities of the original instruments, especially if they had to be used in a performance.

There are different reasons while rebuilding Russolo's instruments is interesting. First of all, studying these instruments allows to achieve a better understanding of their sound production mechanism. Moreover, preserving these instruments is important from a cultural heritage perspective. Nowadays, although some people might have heard of Russolo's Intonarumori, few are able to describe their design and their sound production mechanism. Since all the original instruments have been destroyed, and few reconstructions are present around the world, it is important to preserve such important contribution to the musical heritage of the 20th century.

8. ACKNOWLEDGMENTS

The authors would like to acknowledge the anonymous reviewers for their useful comments and composer Juraj Kojs who will use the Croaker in his music.

9. REFERENCES

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

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

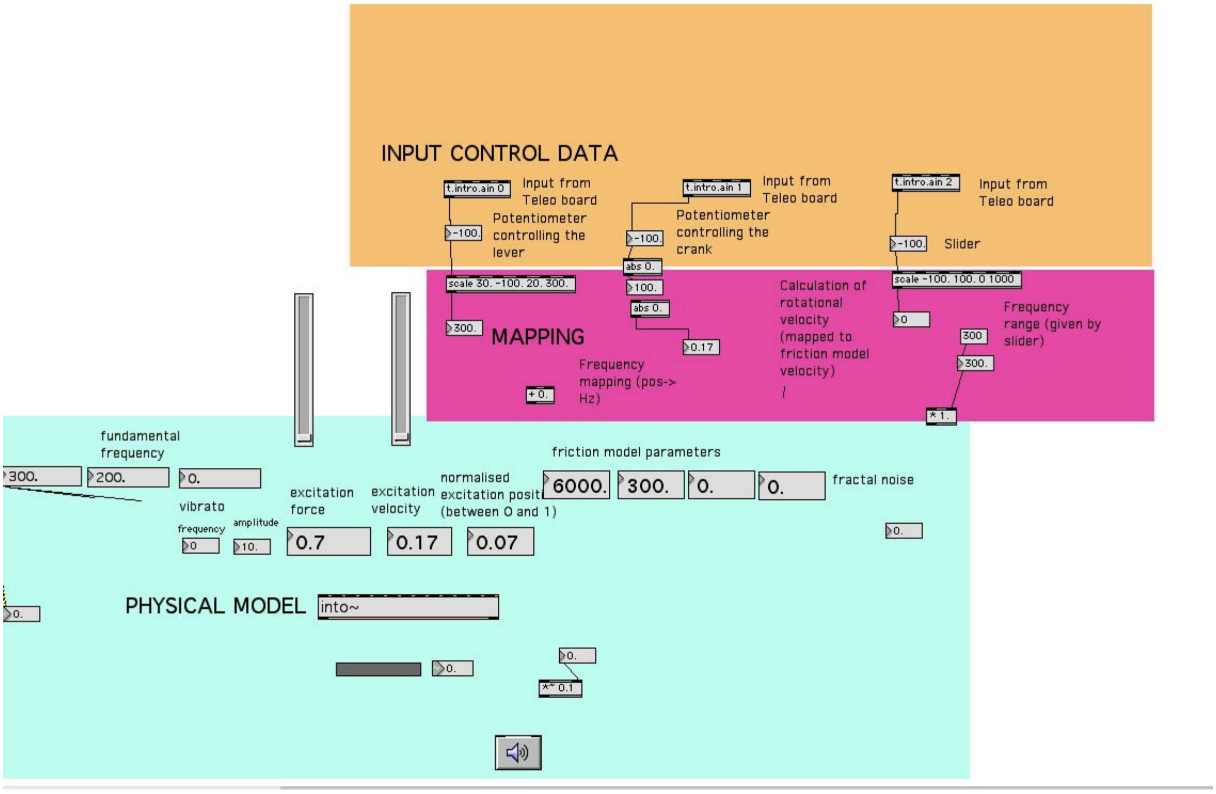

Figure 10: Max/MSP patch which implements the sound synthesis engine. Top part (orange): connection between the Teleo microprocessor and Max/MSP. Center (pink): the mapping from sensors data to the sound synthesis engine; bottom (light blue): the sound synthesis engine.

[3] 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*, 13(5), 2005.

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

[5] P. R. Cook. Physically informed sonic modeling (phism): Synthesis of percussive sounds. *Computer Music Journal*, 21(3), 1997.

[6] G. D. P. G. Borin and A. Sarti. Sound synthesis by dynamic systems interaction. *Readings in Computer-Generated Music. IEEE Comp. Soc. Press*, 1992.

[7] W. Gaver. Synthesizing auditory icons. In *INTERCHI*, 1993.

[8] G. Maffina. *Luigi Russolo e l'Arte dei rumori, con tutti gli scritti musicali.* Martano editore, 1978.

[9] B. A. P. Dupont, V. Hayward and F. Altpeter. Single state elasto-plastic friction models. *IEEE Transactions on Automatic Control*, 47(5), 2002.

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

[11] X. Rodet. Time-domain formant wave-function synthesis. *Computer Music Journal*, 8(3), 1984.

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

[13] M. Wanderley and N. Orio. Evaluation of input devices for musical expression: Borrowing tools from hci. *Computer Music Journal*, 26(3), 2003.