An Intuitive Synthesizer of Sustained Interaction Sounds

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Abstract. This research, based on the action/object paradigm that proposes that sounds result from an action on an object, focuses on the synthesis of sustained interaction sounds: rubbing, scratching, rolling and nonlinear friction sounds. Thanks to the underlying signal models which are highly controllable, the proposed synthesizer allow the definition of objects and interactions properties from an intuitive graphical interface. The synthesized sounds are controlled in real time by the user's gesture thanks to external controllers and physically informed mappings.

Keywords: Sound Synthesis Control, Rolling, Scratching, Rubbing, Sustained Interaction, Nonlinear Friction, Intuitive Control

1 Introduction

Here we present two interfaces to control sound synthesis models of sustained interaction sounds. The first presented interface is devoted to the control of continuous interactions: rubbing, scratching and rolling [5]. The synthesizer allows the user to create and morph between sounds of these three continuous interactions, and can be controlled thanks to the velocity of a gesture on a graphical tablet. The second presented interface is devoted to the control of nonlinear friction sounds such as squeaking or wineglass singing [16]. The sound synthesis process of nonlinear friction sounds is controlled by the pressure and velocity of the user's gestures.

Both these models are based on a paradigm called *action-object*. This concept, proposed by Gaver [8], assumes that we can model separately the object and interaction properties. It is indeed possible to extract and model perceptually relevant features that allow a listener to recognize, for instance, the material of an impacted object [1], or the perceived interaction [4]. Source-filter modeling

* The authors would to thank the French National Research Agency (ANR) for funding this work under the MétaSon: Métaphores Sonores (Sound Metaphors) project (ANR-10-CORD-0003) in the CONTINT 2010 framework: http://metason.cnrs-mrs.fr/home.html.

is well suited to the implementation of sound synthesis models that respect the *action-object* paradigm, where the object's properties are modeled by the filtering part, which is fed by a source signal modeling the relevant features to perceive a specific interaction. Based on these considerations, some authors of the paper proposed an impact sound synthesizer which can be controlled intuitively by choosing object's properties such as material and shape [2]. In recent studies we proposed an intuitive control of an interaction sound synthesizer which will be briefly presented hereinafter.

2 Sustained Interactions: Rubbing, Scratching and Rolling

Here, we look at a subset of continuous interaction sounds: rubbing, scratching and rolling. Synthesis models for such sounds have already been proposed in previous studies, some based on physical modeling or physically informed considerations [8,9,17,13,15], others on analysis-synthesis schemes [10,11]. In [4], we highlighted the perceptual differences between rubbing and scratching, allowing to extend the friction sounds model proposed by Van den Doel et al. [17] and then synthesize scratching sounds and morph continuously toward rubbing sounds. Based on the results of listening tests on recorded friction sounds, we proposed a simple sound synthesis control allowing to morph continuously from rubbing to scratching. This hypothesis was then validated thanks to a perceptual experiment on synthesized sounds. Rubbing and scratching sounds can be modeled as series of impacts which are lowpass filtered with a cutoff frequency varying proportionally to the velocity of the gesture. Modifying the temporal impact density alters the perceived action : the sparser are the impacts, the more the sound evokes scratching (or the higher the density, the more the sound evokes rubbing). This is schematized in figure 1.

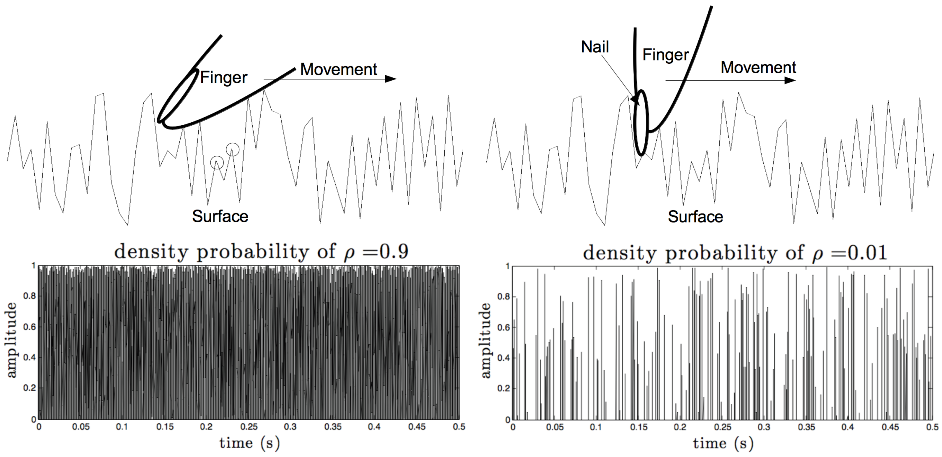

Fig. 1. Top: Representation of the interactions. Bottom: Associated source signals which fed the filters. Left: Rubbing interaction. Right: Scratching interaction.

For the rolling sound synthesis, we proposed in [5] a modeling of the source signal which is also an impact series. This modeling was based on the study of the physics-based model proposed by Rath et al. [13] and on analysis-synthesis of the interaction force between the ball and the surface over which the ball rolls. As the rolling model in [13] is derived from a bouncing one, the impacts are related to each other. Thus, by introducing correlation between the impacts of the rubbing-scratching model previously presented, we can synthesize a sound signal that evokes rolling sounds. Figure 2 displays a synthesized source signal related to the rolling action.

Figure 3 shows the synthesizer interface and a demonstration video is available at: `http://www.lma.cnrs-mrs.fr/~kronland/InteractionSpace/`. Such a tool can be used for many applications, from virtual reality and video games to the study of mental diseases [12].

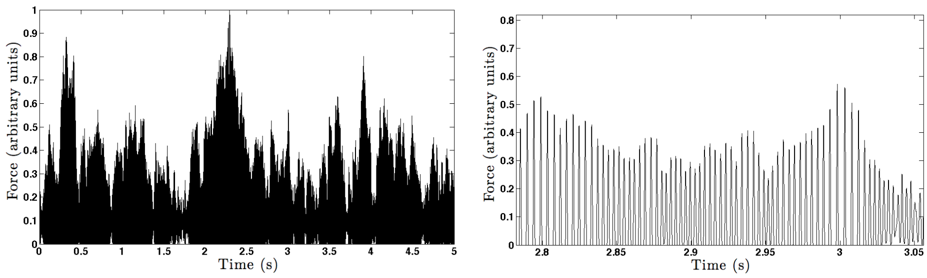

Fig. 2. A synthesized signal evoking rolling sounds (left) and a zoom on this force signal (right), showing that it is an impact series.

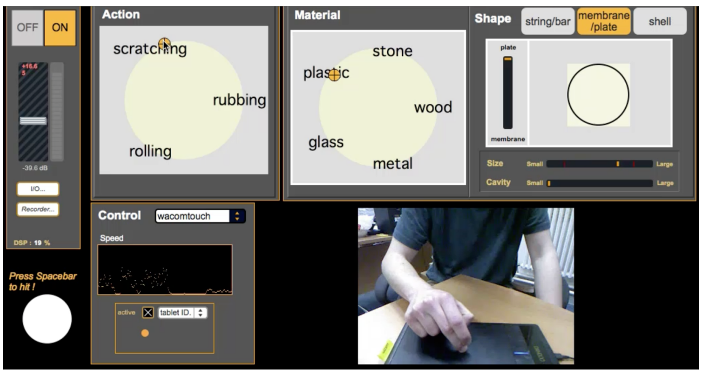

Fig. 3. The synthesizer interface. On the left is the control of the perceived interaction and on the right the control of the object (material, shape...).

3 Nonlinear Friction Sounds

The second interface focuses on the synthesis of nonlinear friction phenomena. Such phenomena appear when two coupled objects are interacting with strong forces and produce sounds like squeaky doors, or brake squeal, but also in the physics of bowed string instruments [14]. The physical modeling of such interactions has been widely studied and efficient models enable to synthesize such sounds from physical parameters [3]. These models are accurate but hardly controllable. It is thus particularly difficult to propose a high level control of the different types of nonlinear interactions.

As in the case of rolling, scratching and rubbing, we used the action-object paradigm and calibrated the resonators according to [2] to model the resonant object. The source designed to simulate such sounds was based on acoustic considerations and signal analysis of recorded squeaks and squeals. A simple signal model has been proposed and enables to simulate the sound produced by different nonlinear phenomena [16][4], and to control it really simply. Two nonlinear interactions are proposed according to two physical behaviors of a glass rubbed by a wet finger: squeaking and self-oscillations. The modeling of the source is made thanks to additive synthesis of a harmonic spectrum whose fundamental frequency varies according to the different acoustic behaviors.

Such a way to synthesize nonlinear interactions allowed to propose a really high level control according to any parameters of a controller. Here we use the pressure and the velocity of a pen on a graphic tablet, which is the most intuitive case but it is possible to control the synthesis with any descriptor captured and computed from an interface. A screenshot of the proposed mapping and the control interface is presented in figure 4.

Such interface led us to envisage many different applications, from tangible musical interfaces to foley applications. Another application in which we are particularly interested is the guiding and learning of specific tasks. As squeaking sounds naturally evoke the sense of effort, it is possible to use it to complete kinesthetic and proprioceptive modalities in the learning of an expert gesture, or to rehabilitate motor diseases. Such a remediation tool is currently being tested in the context of the rehabilitation of a handwriting trouble – dysgraphia – which affects some children who cannot have a fluid writing gesture [6,7].

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[4] Examples are available on the following website: `http://www.lma.cnrs-mrs.fr/~kronland/thoretDAFx2013/`

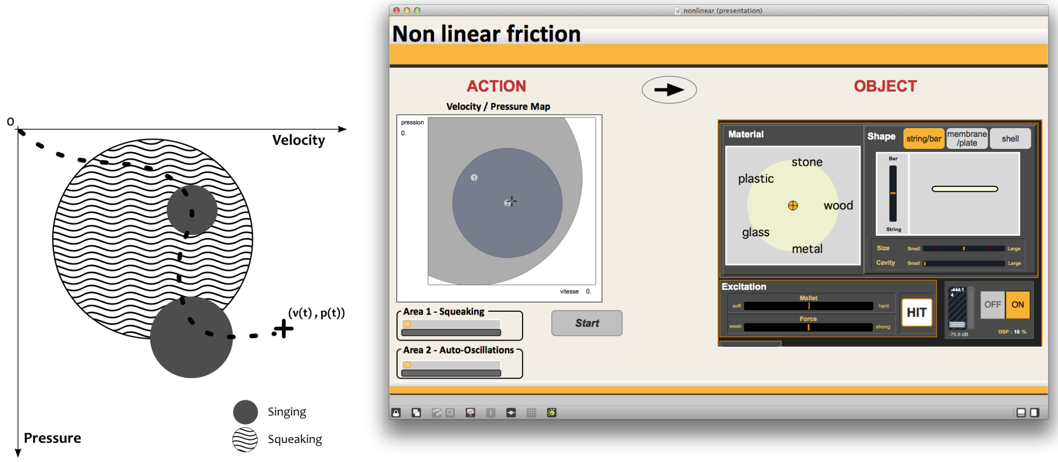

Fig. 4. Mapping between captured parameters and synthesized behavior – Screenshot of the high level control interface

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