Richard Kronland-Martinet
Thierry Voinier
Sølvi Ystad (Eds.)

LNCS 3902

Computer Music Modeling and Retrieval

Third International Symposium, CMMR 2005
Pisa, Italy, September 2005
Revised Papers

Springer

Richard Kronland-Martinet Thierry Voinier
Sølvi Ystad (Eds.)

Computer Music Modeling and Retrieval

Third International Symposium, CMMR 2005
Pisa, Italy, September 26-28, 2005
Revised Papers

Springer

Volume Editors

Richard Kronland-Martinet
Thierry Voinier
Sølvi Ystad
CNRS-Laboratoire de Mécanique et d'Acoustique
31, chemin Joseph Aiguier, 13402 Marseille Cedex, France
E-mail: {kronland, voinier, ystad}@lma.cnrs-mrs.fr

Library of Congress Control Number: 2006925114

CR Subject Classification (1998): H.3, H.4, H.5, H.2, I.2, C.3

LNCS Sublibrary: SL 3 – Information Systems and Application, incl. Internet/Web and HCI

ISSN	0302-9743
ISBN-10	3-540-34027-0 Springer Berlin Heidelberg New York
ISBN-13	978-3-540-34027-0 Springer Berlin Heidelberg New York

Springer is a part of Springer Science+Business Media

springer.com

Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India
Printed on acid-free paper SPIN: 11751069 06/3142 5 4 3 2 1 0

Preface

This volume constitutes the post-proceedings of the 2005 Computer Music Modeling and Retrieval Symposium (CMMR2005). This event took place during September 26–28, 2005 at the Institute of Information Science and Technologies (ISTI), Italian National Research Council (CNR), Pisa, Italy. CMMR is an annual event focusing on various aspects of computer music. CMMR2005 is the third event in this series. The previous event, CMMR2004, was held in Esbjerg, Denmark, while CMMR2003 was held in Montpellier, France. The CMMR 2003 and CMMR 2004 post-symposium proceedings were published by Springer in the *Lecture Notes in Computer Science* series, LNCS 2771 and LNCS 3310, respectively. CMMR2005 was jointly organized by Laboratoire de Mécanique et d'Acoustique (LMA), Centre National de la Recherche Scientifique (CNRS), Marseille, France and ISTI, CNR, Pisa, Italy.

The field of computer music is interdisciplinary by nature and closely related to a number of computer sciences and engineering areas such as information retrieval, programming, human computer interaction, digital libraries, hypermedia, artificial intelligence, acoustics, signal processing, etc. In this year's CMMR we wanted to emphasize the human interaction in music, simply the PLAY, meaning that papers related to sound modeling, real-time interaction, interactive music, perception and cognition were encouraged. The traditional themes related to information retrieval, programming, digital libraries, and artificial intelligence of course also constituted an important part of the conference as they did in the two previous conferences. The large variability of topics led to fruitful discussions gathering specialists from different fields.

As a novelty in CMMR2005, music contributions were made possible. Various nontraditional, real-time interfaces were presented and used during a concert in the CinemaTeatroLUX in Pisa.

We would first of all like to thank Leonello Tarabella and Graziano Bertini for being the Symposium Chairs, and Massimo Magrini and Stefano Giorgetti for helping with local arrangements and technical support. We would further like to thank the Program Committee members for their crucial paper reports, and all the participants, be it scientists or composers, who contributed with papers and music and made the CMMR2005 a varied and inspiring event. Finally, we would like to thank Springer-Heidelberg for accepting the publication of the CMMR2005 post-proceedings in their LNCS series.

December 2005

Richard Kronland-Martinet
Sølvi Ystad
Thierry Voinier

Organization

CMMR 2005 PLAY! was jointly organized by CNR-Pisa, Italy, and LMA-CNRS Marseille, France.

Symposium Chairs

Leonello Tarabella (CNR, Pisa, Italy)
Graziano Bertini (CNR, Pisa, Italy)

Proceedings Chairs

Richard Kronland-Martinet (CNRS-LMA, Marseille, France)
Sølvi Ystad (CNRS-LMA, Marseille, France)
Thierry Voinier (CNRS-LMA, Marseille, France)

Local Arrangements and Technical Support

Graziano Bertini (CNR, Pisa, Italy)
Stefano Giorgetti (CNR, Pisa, Italy)
Massimo Magrini (CNR, Pisa, Italy)
Leonello Tarabella (CNR, Pisa, Italy)

Program Committee

Program Chair
Sølvi Ystad (CNRS-LMA, Marseille, France)

Members
Jens Arnspang (Aalborg University, Esbjerg, Denmark)
Graziano Bertini (CNR-Pisa, Italy)
Mireille Besson (CNRS-INCM, Marseille, France)
Vittorio Cafagna (University of Salerno, Italy)
Antonio Camurri (University of Genoa, Italy)
Giovanni DePoli (CCS University of Padova, Italy)
Barry Eaglestone (University of Sheffield, UK)
Anders Friberg (Royal Institute of Technology (KTH), Sweden)
Philippe Guillemain (CNRS-LMA, Marseille, France)
Cynthia M. Grund (University of Odense, Denmark)
Goffredo Haus (University of Milan, Italy)

Henkjan Honing (University of Amsterdam, The Netherlands)
Kristoffer Jensen (Aalborg University Esbjerg, Denmark)
Uffe Kock-Wiil (Aalborg University Esbjerg, Denmark)
Richard Kronland-Martinet (CNRS-LMA, Marseille, France)
Marc Leman (University of Gent, Belgium)
Stephen McAdams (Faculty of Music, McGill University, Canada)
Julius Orion Smith III (Stanford University, USA)
Xavier Rodet (IRCAM, Paris, France)
Gary Scavone (Faculty of Music, McGill University, Canada)
Johan Sundberg (Royal Institute of Technology (KTH), Sweden)
Leonello Tarabella (CNR, Pisa, Italy)
Thierry Voinier (CNRS-LMA, Marseille, France)
Gerhard Widmer (University of Vienna, Austria)

Music Selection Chair
Leonello Tarabella (CNR, Pisa, Italy)

Table of Contents

Interactive Music: Gestures and Sensors

Interactive Music: Music Composition

Music Retrieval: Music Performance

Music Retrieval: Music Analysis

Music Retrieval: Music Representation

Interdisciplinarity and Computer Music

Dynamic Simulation of Note Transitions in Reed Instruments: Application to the Clarinet and the Saxophone

Philippe Guillemain and Jonathan Terroir

CNRS - Laboratoire de Mécanique et d'Acoustique,
31, chemin Joseph Aiguier, 13402, Marseille cedex 20, France
{guillem, terroir}@lma.cnrs-mrs.fr
http://www.lma.cnrs-mrs.fr

Abstract. This paper deals with the simulation of transitions between notes in the context of real-time sound synthesis based on physical models of reed instruments. For that purpose, both the physical and the subjective point of view are considered. From a physical time-varying tonehole model a simple transition model is built, the parameters of which are adapted in order to fit with measurements obtained in normal playing situations. The model is able to reproduce the main perceptive effects, both from the listener point of view, which is a frequency glissando, loudness and brightness variations, and from the player point of view, which is a reduced ease of playing during the transition.

1 Introduction

Sound synthesis based on a modeling of the physical behavior of musical instruments is known to be able to reproduce most of the dynamic aspects of the control of the instruments. It is specifically useful for self-oscillating instruments such as woodwinds or bowed strings instruments, for which the musician has under his control several continuous parameters that act on the pitch, loudness and timbre of the instrument. On these instruments, the simulation of transitions between different pitches is a crucial problem, since a continuous sound production during the closing or opening of toneholes occurs very often in the musical play. For reed instruments, the dynamics of the transition itself can be considered as a part of the musical performance, since the player can decide at what speed the holes are opened or closed. Moreover, transitions have noticeable effects from the point of views of both the player and the listener. The player observes a reduced ease of playing, while the listener may perceive a glissando in frequency during a slow closing or opening, together with variations in the intensity and the brightness of the sound.

In this paper, we present a study the aim of which is to propose a very simple but realistic transition model adapted to the real-time synthesis and control of the clarinet using physical models such as those developed by Guillemain et al. [6]. This study extends the results described in [14] thanks to the comparison with natural sounds and the application of the method to the tenor saxophone.

R. Kronland-Martinet, T. Voinier, and S. Ystad (Eds.): CMMR 2005, LNCS 3902, pp. 1–23, 2006.

Experimental signals obtained in usual playing situations of a natural instrument are first considered . In order to get rid of possible artifacts due to a human play, we consider note transitions requiring the closing or opening of a single hole. From the analysis of these signals, we show that the shapes of the frequency glissando, the perceived intensity and the brightness are identical in the closing or opening phases and are independent of the speed at which a tonehole is closed or opened, up to a scaling factor in time.

The next section deals with the physical modeling of the dynamic closing of a tonehole. Many studies have been devoted to the study of toneholes (see for example [9], [11] or [3]). Benade [1] showed that the equivalent length of a single hole pipe is directly function of the geometric properties of the hole. Keefe [10] studied the influence of the size of the holes on frequency, amplitude and playing characteristics. Dalmont and al. [2] have shown how the size of the hole can modify the perceived pitch, timbre and energy. The knowledge of how the hole modifies the behavior of the instrument is essential but what happens during the closing is very important too. Nederveen [12] has considered the influence of the key during the closing, so as Ducasse [4], who has implemented a model of progressive closing of the tonehole, and Scavone and Cook [13] who simulate the closing by varying the reflectance filter of the tonehole between its fully open value and a value nearly equal to one (corresponding to the reflection of the pressure wave at the closed end of the hole). Here, we restrain ourselves to a very simple model, made of a perfectly cylindrical bore and a single, small, opened side-branch with time-varying radius. We show that despite its simplicity, this model is sufficient for the reproduction of the loss of ease of playing, induced by a loss of harmonicity of the impedance peaks and a decrease in the amplitude of the first peaks.

In the next sections, we propose a simplified implementation of this model for use with real-time synthesis, based on an interpolation between the difference equations corresponding to two different resonator lengths. The interpolation coefficients are finally adapted in order to fit with the experimental signals.

The validity of the transition model is checked for conical bores by comparing natural and synthesized saxophone sounds. Last section is devoted to conclusions and perspectives of this work.

2 Experimental Results on the Clarinet

2.1 Experimental Protocol

Measurements have been done on a B-flat clarinet (Yamaha YCL250). In order to observe how the perceived sound is changing during the tonehole closing (or opening), the external pressure has been measured. First, the musician has been asked to close (or open) the first tonehole closed by a “perforated key” (corresponding to the transition from G2 to F2) so as he may close it by bringing closer the finger to the hole until the finger fully closes the hole, as he does during a normal performance, or by sliding his finger so as it progressively reduces the surface of the hole. The second closing technique was used since it can be modelled as a dynamic reduction of the tone hole radius. In order to investigate if the behavior of the transition changes with the closing speed or the kind of action (closing or opening) the musician has been asked to perform the closing and the opening for several speeds (from very slow to very fast). The measurements have been done with an omnidirectional KU81 Neumann in a semi-anechoic room, installed one meter away face to the musician, in order to capture what a listener is hearing.

2.2 Objective Parameters

In this section, we consider objective parameters linked to the behavior of the measured signals, namely the frequencies and amplitude variations of the harmonics during the closing of a tonehole, as functions of the speed or the kind of action (closing or opening).

Frequency of the Harmonics. Figure 1 shows the spectrogram of a measured signal for a slow closing from $G2$ to $F2$ fingering.

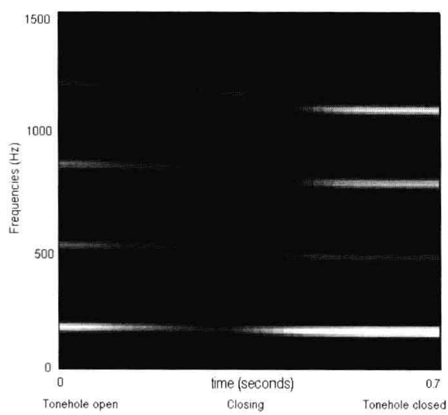

Fig. 1. Spectrogram of a measured external pressure signal obtained for a slow closing from G2 to F2 fingering

Figure 1 clearly shows a frequency glissando. This result is in agreement with the description of the musicians mentioned e.g in [2] or [4]. In order to check if this behavior is the same for each speed or when opening the tonehole, the musician has been asked to close the tonehole with different speeds from very slow to very fast. The figure 2 shows how the frequency of the first harmonic is changing during the closing for four different closing speeds and for one opening (the curve is reversed for an easier comparison). The duration of the closings are $800ms$ and $700ms$ for the very slow closings, $300ms$ for the medium one, $150ms$ for the fast one and $90ms$ for the fast opening. These estimated values correspond to the duration between the two stationary pitches. For each sound, only the closing duration has been considered and an appropriate linear time

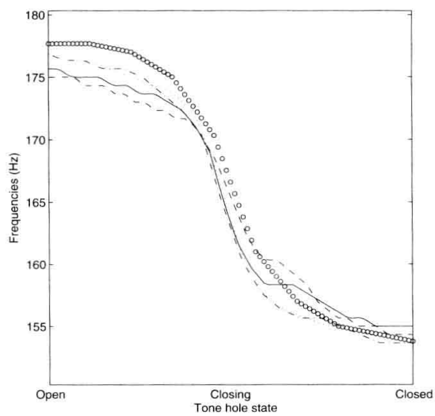

Fig. 2. Variations of the frequency of the first harmonic of measured external pressure signals for different tonehole closing speeds and for a fast opening. Slow closing: solid line and dotted line; intermediate closing speed: dotted line; fast closing: dashed-dotted line; fast opening (reverse curve): circles.

scaling makes it possible to superimpose all the curves in order to allow us to easily compare the different behaviors. One can notice that for each external pressure signal the curves are very similar. Thus, in a synthesis context, this suggests that it is possible to control a transition model only by its duration.

In order to confirm that the frequency of the first harmonic is always varying in a similar way, a second musician has been asked to play some additional sounds with a different instrument. As the first player, the second one recorded slow tonehole closing by sliding his finger or bringing the finger closer to the hole. As it is shown on figure 3, one can notice similar frequencies variations for each musician. Moreover it is important to notice that the two different techniques the musicians have been asked to use are giving similar frequency variations. The frequency variations of the fundamental seems to be a robust parameter always leading to a similar behavior.

Amplitude of the Harmonics. Let us consider now the variations of the amplitudes of the harmonics during the transition. Since the radiation of the instrument depends on the frequency, the directivity and location of the microphone and the position of the musician, the recording conditions (and consequently the listening ones) play a very important role on the amplitude variations of each harmonic that are observed. Moreover, some aspects can have a strong influence on the variations of the level of the harmonics. First, one can mention physical aspects such as localized nonlinearities that may happen for high blowing pressures or direct excitation of the air column at the location of the tonehole induced by the shock of the finger or the key pad for very fast closings. The second aspect is the "human factor". For each recorded sound, there is a variability of the control parameters such as the blowing pressure and the average

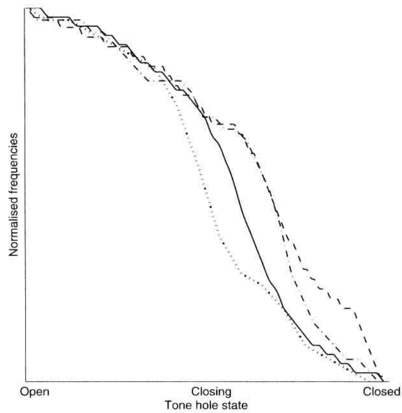

Fig. 3. Variations of the frequency of the first harmonic of measured external pressure signals for different tonehole closing techniques with two different musicians. Solid line: variations obtained by bringing closer the finger to the hole (musician 1); dotted line: variations obtained by sliding the finger on the hole (musician 1); dashed line: variations obtained by bringing closer the finger to the hole (musician 2); dashed-dotted line: variations obtained by sliding the finger on the hole (musician 2).

opening of the reed channel. The musician does not blow or press the reed the same way for each sound he produces. Indeed, after the recordings, we asked the musician to comment the difficulty of the task. The first remark was related to the "unconscious" adjustment of the control parameters in order to prevent the raising of squeaks during slow closings (though the main instruction was to keep the control parameters as constant as possible). The second remark was linked to the way the tonehole closing was done. The instruction was to close it continuously with a constant velocity of the finger, but musicians admitted that because of the sensation on the finger and the risk of squeaks, it was very difficult to keep the velocity constant. For all these reasons, it seems difficult to use the variation of the amplitude of each individual components. Moreover, in a synthesis context, the question is not "does a simplified model acts as a real instrument ?" but rather "what kind of behavior must be in agreement with the perception of natural sounds?". Careful listening to the recorded sounds gives two important and reproducible sensations : the glissando effect previously studied and the sensation that the intensity and the brightness of the sound are first decreasing and then increasing. In order to quantify these variations of the perceived sound intensity, we shall consider the global subjective parameters, rather than the individual levels of the harmonics.

2.3 Subjective Parameters

Loudness
According to Zwicker [18], the subjective parameter directly linked to the perceived intensity of the sound is the loudness. Figure 4 shows how the loudness of

the measured signals is varying for the two musicians and several closing techniques. It is worth noticing that the loudness is well defined only for stationary signals. For the purpose of this study, we have considered the non stationary signal during the transition as a succession of stationary signals with a $22ms$ duration. Though the perceptive relevancy of the loudness in such a situation might be questionable, it constitutes a computation tool that allows an objective comparison between signals.

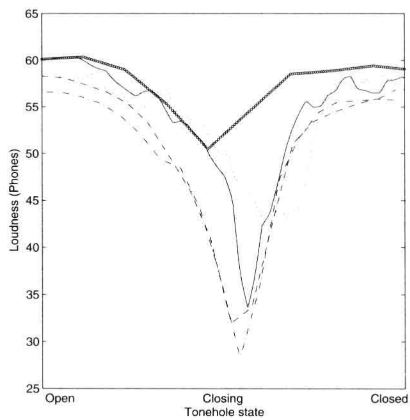

Fig. 4. Variations of the loudness of measured external pressure signals for different tonehole closing speeds and for a fast opening. Slow closing: solid line and dotted line; intermediate closing speed: dashed line; fast closing: dashed-dotted line; fast opening (reverse curve): points.

Similarly to the frequency variations, figure 4 shows that the loudness of the measured signals has a typical shape. One can notice a "valley" which corresponds to a decrease of the perceived intensity. In order to evaluate the influence of the location of the microphone (and consequently of the listener) the sounds have been recorded simultaneously with a directive microphone hanged on the bell of the clarinet. This way, the external pressure is directly measured at the open end of the clarinet. This measure shows that the loudness variations are similar for the two microphones, even though the amplitudes of the harmonics have very different behaviors in the two measures (due to the microphone location and the toneholes radiation).

Brightness

As it has been previously mentioned a careful listening of the sound variation during the tonehole closing shows that the reduction of the loudness comes with a fall of the "brightness" of the sound. Some previous studies have shown that the spectral centroid is one of the parameters directly linked to the notion of "brightness" [5]. The brightness can be expressed as follows (equation 1), with f_i

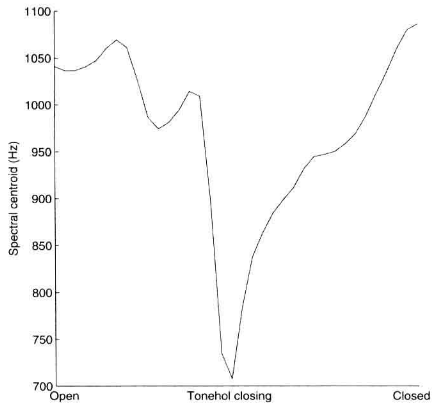

Fig. 5. Variations of the spectral centroid of a measured external pressure signal

the frequency of the i^{th} component, A_i its amplitude and N the number of components taken into account. N corresponds to the last harmonic the amplitude of which is greater than a given threshold.

$$SG = \frac{\sum_{i=1}^{N} f_i A_i}{\sum_{i=1}^{N} A_i} \tag{1}$$

Figure 5 shows the variations of the spectral centroid during a slow tonehole closing performed by a musician. According to him the control parameters have been kept as constant as possible. One can notice that there is a decrease of the spectral centroid during the closing. It means that the brightness of the sound is reduced during the transition. This is in accordance with the perceptive effect we previously mentioned. Moreover this kind of behavior is independent of the technique (sliding / bringing closer), the kind of action (closing / opening) or the speed. Nevertheless it is worth noticing that the values of the spectral centroid depends on the playing conditions (e.g. blowing pressure).

In the next sections, we shall study a physical dynamic tonehole model, simplify its implementation so that it is compatible with real-time synthesis and adapt its parameters in order to reproduce the frequency and loudness variations observed on the natural transition sounds.

3 Simplified Physical Model

3.1 Bore Model

We use a cylindrical pipe with a single hole (see figure 6). It is an oversimplified model of a clarinet body that, according to Benade [1], only considers the role of the first open hole and ignore the others. From a synthesis point of view, such a model seems also sufficient. Indeed, modeling a tonehole lattice with dynamic