Eleni Efthimiou
Georgios Kouroupetroglou (Eds.)

Gesture in Embodied Communication and Human-Computer Interaction

9th International Gesture Workshop, GW 2011
Athens, Greece, May 25-27, 2011

Institute for Language and Speech Processing / ATHENA RC

National and Kapodistrian University of Athens

Title: **Gestures in Embodied Communication and Human – Computer Interaction**

9th International Gesture Workshop, GW 2011

Editors: Eleni Efthimiou, Georgios Kouroupetroglou

Edited at: Accessibility Unit for Students with Disabilities
National and Kapodistrian University of Athens

Printed by: National and Kapodistrian University of Athens

Published: 2011
by National and Kapodistrian University of Athens
Panepistimiopolis, Ilisia, GR-15784 Athens, Greece
e-mail: access@uoa.gr
http://access.uoa.gr

ISBN 978-960-466-075-9

Simple Cases of Low Cost Force-Feedback Interaction with Haptic Digital Audio Effects

Alexandros Kontogeorgakopoulos[1], Georgios Kouroupetroglou[2]

[1] Cardiff School of Art and Design, University of Wales Institut Cardiff
Llandaff Campus, Western Avenue, Cardiff, CF5 2YB, United Kingdom
akontogeorgakopoulos@uwic.ac.uk

[2] National and Kapodistrian University of Athens,
Department of Informatics and Telecommunications, GR-15342 Athens, Greece
koupe@di.uoa.gr

Abstract. We present the results of an experimental study of Haptic Digital Audio Effects with and without force feedback. Participants experienced through a low cost Falcon haptic device two new real-time physical audio effect models we have developed under the CORDIS-ANIMA formalism. The results indicate that the haptic modality changed the user's experience significantly

Keywords: haptics, digital audio effects, physical modeling, CORDIS-ANIMA

1 Introduction

Recently, a Haptic Signal Processing platform has been developed which enables musicians, researchers and developers in the field of sound and music computing, to design haptic musical instruments using standard physical modeling formalisms [1]. Therefore a plethora of audio physical models, which have been conceived in the past using general purpose programming languages or more specialized software like the GENESIS software [2], can be implemented elegantly using common wide spread graphic programming environments like MAX MSP [8] or Pure Data [9] visual programming languages for interactive music. Interestingly, these models and particularly those based on the CORDIS-ANIMA simulation engine for dynamic phenomena [3], can be easily controlled using various haptic devices. Among them, the Phantom Premium (by Sensable Technologies) [10] consists of a well known, but rather expensive, device. Last years, a new low cost haptic device, the Falcon (by Novint Inc.) [11], has been launched mainly targeting the broad gaming market. A recent study [12] that compares these two devices based on a Fitts' law targeting task [13], as described in ISO 9241-9 [14], showed that the Falcon has a higher damping than the Phantom, but there are no significant differences between them when taking completion time and error rate into account.

In this paper we present new real-time versions and implementations of two physical audio effect models, which provide force feedback to the performer, based on designs that have been proposed in the past [5]. An experimental study with a simple user interface has been developed which lets the users experience and compares the models with and without the force feedback using a typical and generally accessible setup with the Falcon haptic device. We use the term *Haptic Digital Audio Effects* to refer to sound modification algorithms that provide force feedback to the user (an article relevant to the theory, the concept and the design of haptic audio effect is currently prepared by the authors for future publication).

2 Models

The two novel digital audio effects *Tremolo Model* and *Switch Model* we have developed modify the amplitude of the processed sound in a physical way. The models incorporate an appropriate system structure that supports the physical instrumental interaction paradigm [6] by providing the necessary gestural/haptic input-output ports. The CORDIS-ANIMA (CA) modeling and simulation system, which is based on the mass-interaction physical modeling approach [3], has been employed for both digital audio effects, presented here in a briefly way. The reader who wishes a better understanding of the technical aspects of the proposed digital audio effects is advised to consult the work presented in [5] which offers more details related to the algorithm and the modeling formalism.

The CA *Tremolo Model* is a physical realization or interpretation of the amplitude modulation / ring modulation process for low frequency carrier-signals [7]. For the range of frequencies less than 20Hz, this audio effect is called tremolo. The model uses simple simulated mechanical oscillators, nonlinear springs and it is passive. This feature guaranties the energetic coupling between the user and the system, which is essential in the instrumental interaction.

In the CA *Switch Model*, our concept was to provide a physical model that implements an ON/OFF amplitude switch. The algorithm exhibits similarities with plucked stings or plucked oscillator models, like a hand that “holds” a sound. As an illustrative example of this concept, we can imagine a hand that holds a speaker (massless in this model) and “attach” it to a vibrating structure that diffuse it as the resonance box of string musical instrument, like a guitar. As with the *Tremolo Model*, it uses a nonlinear spring and it is passive. In Figure 1 we illustrate the simplest version of the *Switch Model*, implemented with MAX MSP and controlled with the Falcon haptic interface.

3 User Experience Study

A preliminary research was undertaken to evaluate the user experience with a small number of participants. The goal was to identify if the proposed system was easier, more accurate, more musically expressive and more pleasant with or without the force feedback enabled in the user physical interface. Our ambition was not just to give to the user notable haptic tricks correlated with the audio processing algorithms but to design a system that has subtle instrumental qualities. In order to acquire information about a person's response when using the proposed musical signal processing algorithms, participants were asked to give their opinion scores (in a 1 to 5 scale) on a simple questionnaire after the completion of each of the following tasks:

Task 1: Try to increase or decrease the sound intensity of the music track rhythmically by using the three-dimensional Falcon device and the *Tremolo Model*. Repeat the test as many times as you want, by activating and deactivating the force feedback consecutively and by changing the tempo of the track. Do not stop holding the joystick during the tests because its purpose is to vary the intensity continuously.

Task 2: Try to "tune" the device right in order to hear clearly the music track by using the three-dimensional Falcon device and the *Switch Model*. Then turn on and off rhythmically the musical piece ("tune" and "detune"). Repeat the test as many times as you want, by activating and deactivating the force feedback consecutively and by changing the tempo of the track.

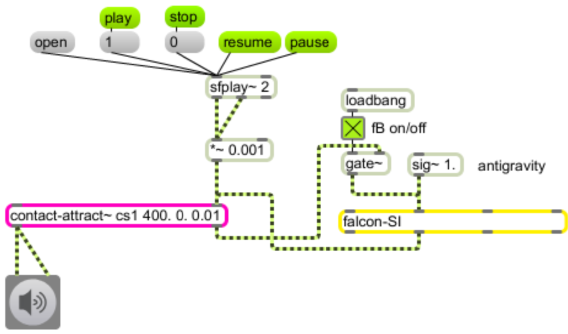

Fig. 1. Max MSP patch for the switch model. A more usable graphic user interface has been developed for the demonstration.

The experimental apparatus include a Novint Falcon haptic device (Figure 2) connected to an Apple MacBook Laptop running MAX MSP Ver. 5 along with a pair of studio monitors. The sound files used during the experiment were various tracks from the of electronic popular music genre.

Five male participants and one female, all active musicians, volunteered for the study. Their age range was 31 to 32 years (mean 22.5). All had normal hearing and were right-handed. No one of the participants had any previous experience with the Falcon haptic device. Moreover, participants moreover took part in a one hour group discussion regarding their experience in the end of the session.

Table 1 presents the overall results of our study for all the participants (Mean Opinion Score).

Fig. 2. The Falcon haptic device (by Novint Inc.).

4 Conclusion

The proposed implementation of the *tremolo* and the *switch* digital audio effects offer the opportunity to experience and perform such a simple musical sound transformation systems in a novel instrumental and mechanical way. It was evident that the haptic modality changed the user's experience significantly; we believe that it will possibly affect, ameliorate and generally enhance the experience of the - so common nowadays- electronic music performances based on digital audio effects. The importance of instrumental and haptic control in the proposed digital audio effects must be verified in the future by formal observations and experiments and by less formal/less controlled conditions such as during a musical performance.

Table 1. Results of the user experience study.

	Mean Opinion Score	
	Task 1	Task 2
It is musically more expressive to modify the sounds with the force feedback rather than without it	3,2	3
It is easier to modify the sounds with the force feedback rather than without it	2,5	2,2
It is more pleasant to modify the sounds with the force feedback rather than without it	3,5	3,8
It is more accurate to modify the sounds with the force feedback rather than without it	3,2	3

References

1. Berdahl, E., Kontogeorgakopoulos, A., Overholt, D.: HSP v2: Haptic Signal Processing with Extensions for Physical Modeling. In Proceedings of the 5th International Workshop on Haptic and Audio Interaction Design - HAID, Sept. 16-17, 2010, Copenhagen, pp. 60-62 (2010)
2. Castagne, N., Cadoz, C. : GENESIS: A Friendly Musician-Oriented Environment for Mass-Interaction Physical Modeling. In Proceedings of the International Computer Music Conference - ICMC, September 17-21, 2002, Goteborg, Sweden, pp. 330-337 (2002)
3. Cadoz, C., Luciani, A., Florens, J.-L.: CORDIS-ANIMA: A modeling and Simulation System for Sound and Image Synthesis – The General Formalism. Computer Music Journal, 17(1), 19-29 (1993)
4. Berdahl, E., Niemeyer, G., and Smith, J.: A Simple and Effective Open-Source Platform for Implementing Haptic Musical Instruments, In Proceedings of the of the 9th International Conference on New Interfaces for Musical Expression - NIME, June 4–6, 2009, Pittsburgh, Pennsylvania, USA, ACM Press, pp. 262-263 (2009)
5. Kontogeorgakopoulos A., Cadoz, C.: Amplitude Modification Algorithms using Physical Models. In 124th Audio Engineering Society Convention, Amsterdam, (2008)
6. Cadoz C., Wanderley, M.: Gesture-Music. In Wanderley M. and Battier M. (Eds) Trends in Gestural Control of Music, IRCAM – Centre Pompidou, pp. 71-94 (2000)
7. Zoelzer U. (Ed): Digital Audio Effects. John Wiley & Sons Ltd, (2002)
8. MAX/MSP http://www.cycling74.com
9. Puckette, Miller Smith: The Theory and Technique of Electronic Music. World Scientific Press, Singapore (2007)
10. Sensable Technologies Phantom, http://www.sensable.com
11. Novint Falcon, http://home.novint.com/
12. Vanacken, L., Joan De Boeck, J., Coninx, K.: The Phantom versus the Falcon: Force Feedback Magnitude Effects on User's Performance during Target Acquisition. Lecture Notes in Computer Science 6306, 179-188 (2010)
13. Fitts, P. M.: The information capacity of the human motor system in controlling the amplitude of movement. Journal of Experimental Psychology, 47(6), 381-391 (1954). Reprinted in Journal of Experimental Psychology: General, 121(3), 262-269, (1992)
14. ISO: Ergonomic requirements for office work with visual display terminals (vdts)-part 9: Req. for non-keyboard input devices. Technical Report 9241-9 (2000)