Interacting with digital resonators by acoustic excitation

Max Neupert
Bauhaus-Universität Weimar
max.neupert@uni-weimar.de

Clemens Wegener
The Center for Haptic
Audio Interaction Research
clemens@chair.audio

ABSTRACT

This demo presents an acoustic interface [1] which allows to directly excite digital resonators (digital waveguides, lumped models, modal synthesis and sample convolution). Parameters are simultaneously controlled by the touch position on the same surface. The experience is an intimate and intuitive interaction with sound for percussive and melodic play.

1. INTRODUCTION

Motivation for the development of the instrument *Tickle* was a more intimate [2] and musical interaction with digital waveguides, lumped models, modal synthesis, sample convolution, as well as feedback-delay lines and filters. Aforementioned synthesis models can be subsumed as digital resonators. The instrument and questions about its driver architecture are discussed in [3] [2] .

2. THE TICKLE INSTRUMENT

2.1 Excitation, Material and Texture

To create an acoustic excitation signal we rely on a hard material that captures the spectra of different gestures. In addition to the rigidity of the material, a textured surface is essential to create enough noise when rubbed and wiped. Silicone surfaces are not suitable for our application since they absorb too much of the subtle interaction. A hard surface allows different spectra to propagate towards the piezoelectric sensor, creating vastly different responses in the digital resonators whether it is hit by a thumb, nail, ring or bowed with a violin bow on its edge. Percussive gestures like hits, knocks, flicks and continuous interactions like rubbing, scratching, or bowing can equally be captured.

2.2 Residual and Resonance

We want the interface to resonate as little as possible, so that we can feed this dry residual signal of the touch gesture as excitation signal into a digital resonator (See also [4]). This way the full power of physical modeling synthesis algorithms may be accessed. The practice of sending generated noise-bursts or clicks into digital resonators which can be found in literature for physical modeling and which is still the standard in many soft- and hardware implementations is crippling the true potential of such algorithms.

2.3 Synthesis

Our synthesis algorithms are implemented as Pure Data patches and are available through our Git repository. [3]

For the sound synthesis we employ techniques of digital reverbrators. They can be understood as modeled simulations (waveguides and mass-spring models) of the physics happening in real instruments as described by Smith [5]. These models can be generated with Berdahl and Smith's Synth-A-Modeler Compiler [6]. Synth-A-Modeler generates FAUST code which can be compiled in a variety of other formats such as a Pure Data external. With the Pure Data object `pmpd~` from Henry's PMPD [7] library which can create static mass and spring models we achieved nice sounding string, plate and gong topologies. Drawback of PMPD is that the topographies and properties of the model can't be interactively modified while sound is processed.

We are not aiming for perfect recreations of orchestral instruments, our interest lies in the exploration of synthetic sounds with an acoustic and intimate level of control. Algorithms like a nested comb filter delay as described by Ahn and Dudas [8] prove interesting and fun to interpret with our instrument while being surprisingly cheap to compute. We can employ our acoustic interface to excite *extended, hybrid* and *abstract cyberinstruments* as described by Kojs et al. [9]. Convolution methods with samples can be useful to digital Foley artists to articulate a sample in a plenitude of variations.

2.4 Gestural Augmentation

To augment the excitation signal from the piezoelectric contact microphone, we gather the X and Y position of the touch event. A touch event lasts from the beginning of a touch until the release. We may also refer to it as a gesture. It can be translated to a note on and off with the note depending on in which hexagon the touch happened. While the gesture is lasting we can derive the X and the Y **offset** from the beginning of the touch event to the current

[1] In the literature the term *hybrid controller* [1] is found
[2] See this earlier publication for further references to related literature as they can't be included in this two-page demo paper
[3] gitlab.chair.audio mirror: github.com/chairaudio

touch position. It is a useful modulation parameter for the synthesis. Naturally this coordinate offset can also be expressed in triangulated *distance* and *angle* between current position and origin of the gesture. Another useful modulation parameter is the speed of the movement.

When moving across the surface of the instrument, it may either be desired to trigger all notes like chimes or only allow the first note (or pitch) to be activated and thus allow for larger gestures extending to the whole surface while still playing the initial note.

Figure 1. *The Tickle instrument*

3. CONCLUSIONS

We believe only a hands-on experience with our instrument can convey the qualitative leap in intuitive control and intimate interaction with a musical instrument.

Testers reported that being able to discern a touch by the finger tip and the nail alone brings the interaction to a new level, that is new to melodic digital interfaces. The spectral and overall loudness response feels very natural and can be compared to that of an acoustic instrument.

Even though our instrument *Tickle* combines several well-known technologies which on their own may not be notable, in their combination they synergize to a powerful intuitive instrument which allows for a natural and intimate interaction with precise and reproducible control over sound. The existing technologies are touch pad, contact-microphone and physical modeling synthesis.

Feeding an analogue excitation signal into a (digital) resonator can create familiar as well as alien sounds. Sounds which either behave like instruments we know: Violin, guitar, snare drum, cymbal, gong, marimba, etc. or sounds which are distinctly synthetic but have an analogue touch to it. In a post-digital environment where "the paradigms analogue and the digital [...] exist simultaneously" [10, P.13] we believe that many new instruments will be seen in this new category of acoustic excitation instruments with digital resonators.

4. REFERENCES

[1] R. Michon and J. O. Smith III, "A Hybrid Guitar Physical Model Controller: The BladeAxe," in *Proceedings of the 2014 International Computer Music Conference*, A. Georgaki and G. Kouroupetroglou, Eds. Athens: International Computer Music Association, 2014, p. 7.

[2] D. Wessel and M. Wright, "Problems and Prospects for Intimate Musical Control of Computers," *Computer Music Journal*, vol. 26, no. 3, pp. 11–22, 2002.

[3] M. Neupert and C. Wegener, "Isochronous Control + Audio Streams for Acoustic Interfaces," in *Proceedings of the 17th Linux Audio Conference (LAC-19)*, CCRMA, Stanford University, Mar. 2019, p. 5. [Online]. Available: http://lac.linuxaudio.org/2019/doc/neupert.pdf

[4] M. Puckette, "Infuriating Nonlinear Reverberator," in *Proceedings of the 2011 International Computer Music Conference*. Huddersfield: International Computer Music Association, 2011, p. 4.

[5] J. O. Smith III, "Physical Modeling Synthesis Update," *Computer Music Journal*, vol. 20, no. 2, p. 44, 1996.

[6] E. Berdahl and J. O. Smith III, "An Introduction to the Synth-A-Modeler Compiler: Modular and Open-Source Sound Synthesis using Physical Models," in *Proceedings of the 2012 Linux Audio Conference*. Stanford: CCRMA, Stanford University, Apr. 2012, pp. 93–99.

[7] C. Henry, "Physical modeling for pure data (PMPD) and real time interaction with an audio synthesis," in *Proceedings of Sound and Music Computing 2004*, Paris, Oct. 2004.

[8] J.-H. Ahn and R. Dudas, "Musical Applications of Nested Comb Filters for Inharmonic Resonator Effects," in *Proceedings of the 2013 International Computer Music Conference*, vol. 2013. Perth: International Computer Music Association, 2013, pp. 226–231.

[9] J. Kojs, S. Serafin, and C. Chafe, "Cyberinstruments via Physical Modeling Synthesis: Compositional Applications," *Leonardo Music Journal*, vol. 17, pp. 61–66, Dec. 2007. [Online]. Available: http://www.mitpressjournals.org/doi/10.1162/lmj.2007.17.61

[10] C. Thorén, M. Edenius, J. E. Lundström, and A. Kitzmann, "The hipster's dilemma: What is analogue or digital in the post-digital society?" *Convergence: The International Journal of Research into New Media Technologies*, vol. 20, no. 10, p. 16, Jun. 2017. [Online]. Available: http://journals.sagepub.com/doi/10.1177/1354856517713139