Ssynth: a Real Time Additive Synthesizer with Flexible Control

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Abstract

This research project concerns the simulation of interpretation in live performance using digital instruments. It addresses mapping strategies between gestural controls and synthesizer parameters. It requires the design and development of a real time additive synthesizer with flexible control, allowing for morphing, interpolating and extrapolating instrumental notes from a sound parameters database. We present the synthesizer, its additive and spectral envelope control units, and the morphing they allow for.

The combination of heavily computational synthesis techniques (e.g. additive synthesis) with gestural control devices in performance situation offers the sound quality of offline applications together with the control quality of real time applications. It however requires to consider synthesis from the control viewpoint, in terms of design and implementation. The *Ssynth* additive synthesizer includes flexible control of additive and source-filter models of sound.

Ssynth implements:
- 3-order phase polynomial model (McAulay and Quatieri, 1986),
- interpolating/extrapolating data from the database, and morphing,
- synthesizing polyphonic sounds,
- handling OSC messages (Wright, 1997) to carry control information,
- implemented in C, can be compiled as a stand alone program or as a Pd object, using the Pd scheduler for output audio.

The **sound parameters database**:
- McGill master samples database (Opolko and Wapnick, 1987),
- additive analysis using standard techniques implemented in *Additive*,
- fundamental frequency estimation using HMM (Doval and Rodet, 1993),
- frames organized as a 3-dimensional mesh as in (Haken, Tellman and Wolfe, 1998) according to pitch, dynamics and instrument,
- instruments: clarinet, oboe, trumpet and saxophone,
- spectral envelope models.

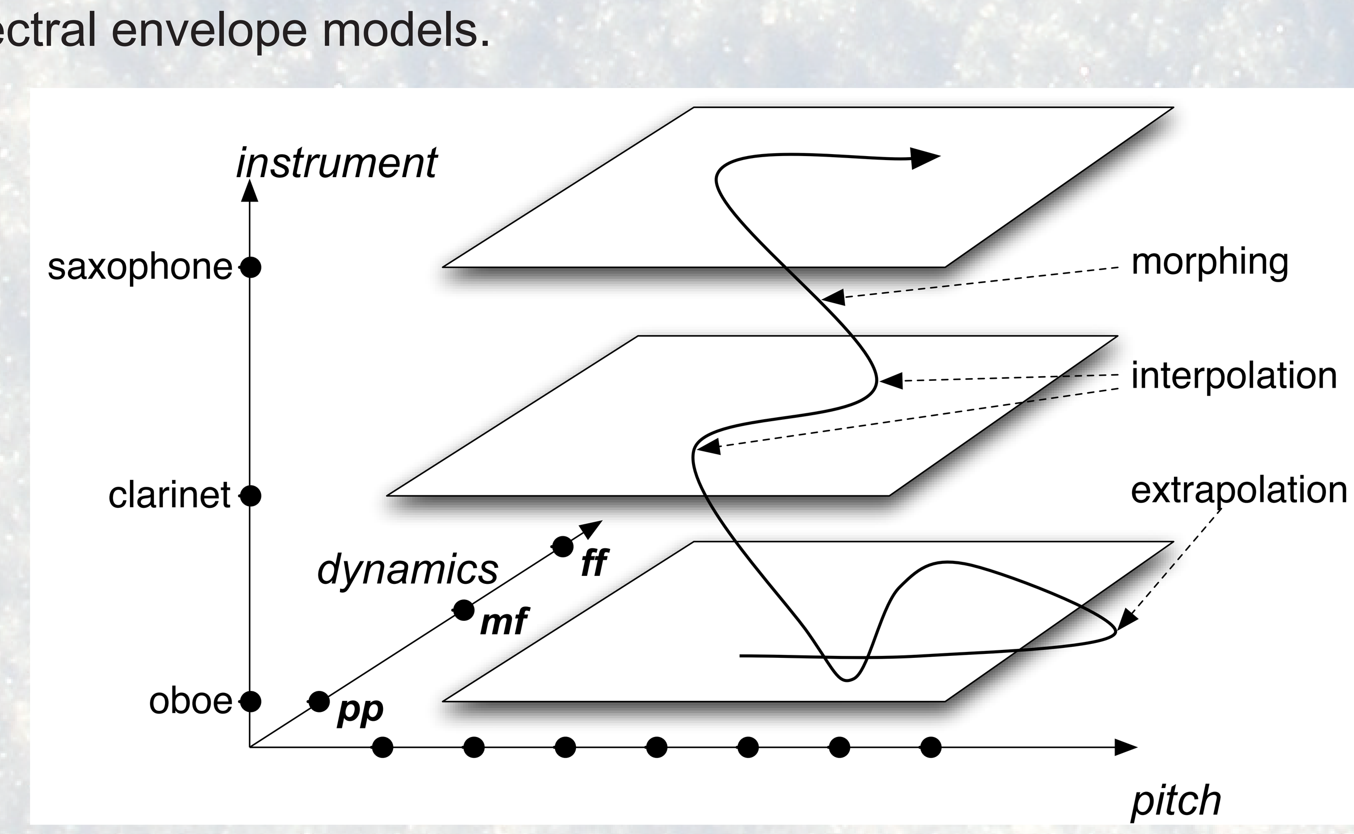

Figure 1: Example of trajectory in the database, involving interpolation and extrapolation of pitch and dynamics, as well as morphing (interpolation between instruments)

Modular mapping structure to provide a gestural control (see Figure 2):
- 1st part: Pd patches converting the transducer data into abstract parameters by rendering the acoustical couplings that exist between lip pressure, air pressure and fingerings, in order to provide fundamental frequency, intensity and dynamics (Wanderley, Schnell and Rovan, 1998).
- 2nd part: additive synthesizer with abstract parameters and spectral envelope parameters input. An internal mapping layer converts the abstract parameters into additive parameters (partials frequencies and amplitudes) by interpolating/extrapolating the database.

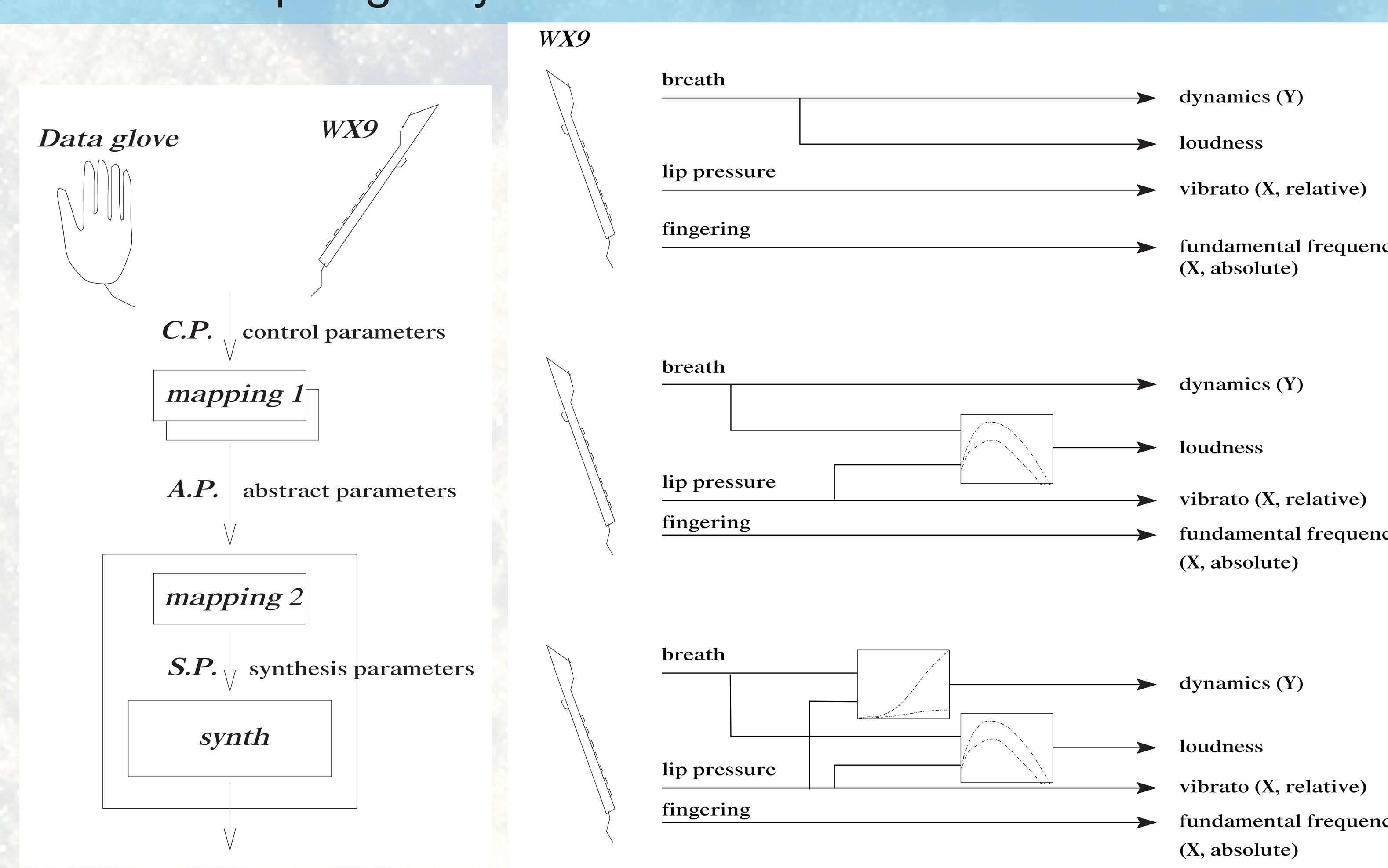

Figure 2: Mapping strategy, involving an abstract parameter layer (left). The first mapping stage (right) simulates coupling between physical parameters (Wanderley et al., 1998)

Controlling additive synthesis

The gestural control of additive synthesis from sound parameters database requires morphing (Depalle, Garcia and Rodet, 1995; Haken, Tellman and Wolfe, 1998) to infer new sounds, since not all sounds exist in the database, in terms of fundamental frequency, intensity and dynamics. Specific morphing strategies are derived from (Tellman, Haken and Holloway, 1995).

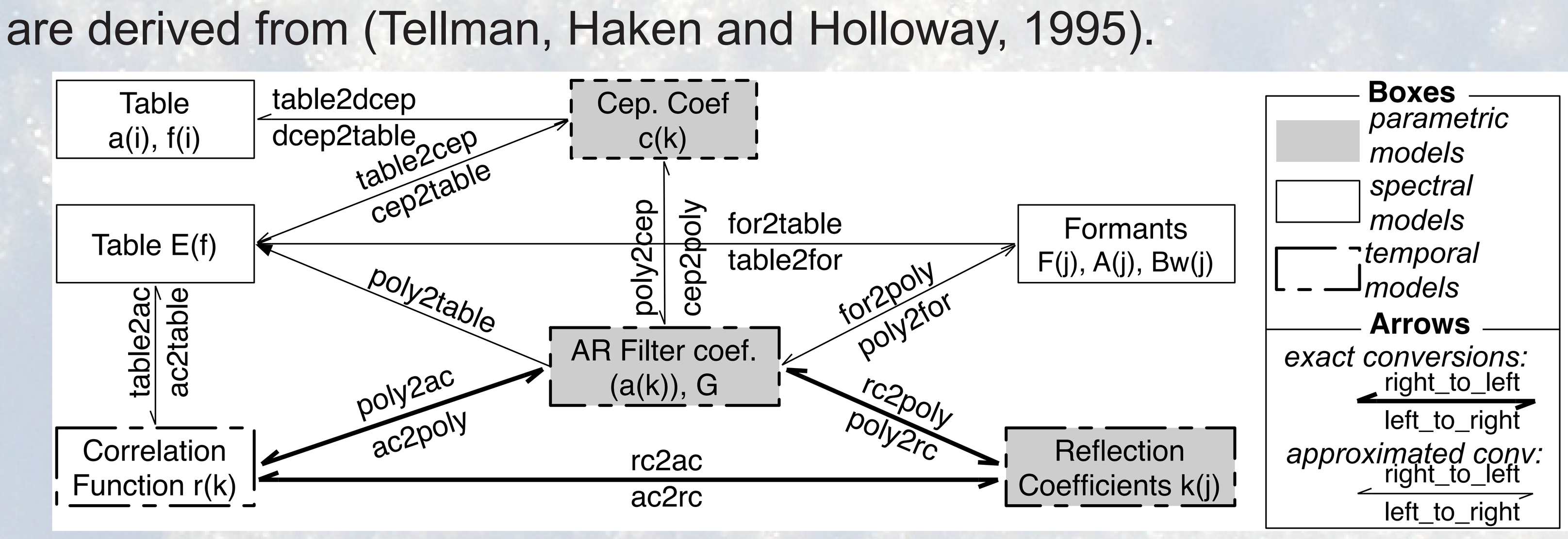

Figure 3: Interoperability system for conversion of spectral envelope representations

Controlling the spectral envelope

The spectral envelope is a function of frequency. It simplifies the amplitude control of partials in Ssynth, and its modification is useful to morph sounds. Gestural control of the spectral envelope may require conversions from one model into another, more suited to provide a spectral envelope corresponding to a stable filter for a given control. Fig. 3 depicts the implemented conversions. Indirect conversions are then derived by combination of basic conversions.

To conclude

In the context of gestural control of additive synthesis for interpolating and extrapolating instrumental notes, our contribution lies in the systematic design of the synthesis environment for allowing flexible control. This implies a potential control of the additive part by spectral envelopes, parameterized in various forms.

Bibliography

Depalle, P., G. Garcia, and X. Rodet (1995). Reconstruction of a castrato voice: Farinelli's voice. In Proc. IEEE Workshop Appl. of Digital Sig. Proc. to Audio and Acoustics, New Palz, USA, pp. 242–5.
Doval, B. and X. Rodet (1993). Fundamental frequency estimation and tracking using maximum likelihood harmonic matching and HMM's. In Proc. IEEE-ICASSP'93, Minneapolis, USA, Volume 1, pp. 221–4.
Haken, L., E. Tellman, and P. Wolfe (1998, Spring). An indiscrete music keyboard. Computer Music J. 22(1), 30 – 48.
Opolko, F. and J. Wapnick (1987). McGill University Master Samples,Montreal, Canada.
Oppenheim, A. V. and R. W. Schafer (1975). Digital Signal Processing. Prentice Hall, Englewood Cliffs.
Schwarz, D. and X. Rodet (1999). Spectral envelope estimation and representation for sound analysis-synthesis. In Proc. Int. Comp. Music Conf. (ICMC'99), Beijing, China, pp. 351–4.
Serra, X. and J. O. Smith (1990). A sound decomposition system based on a deterministic plus residual model. J. Acoust. Soc. Am., sup. 1, 89(1), 425–34.
Tellman, E., L. Haken, and B. Holloway (1995). Timbre morphing of sounds with unequal numbers of features. J. Audio Eng. Soc. 43(9), 678–89.
Wanderley, M., N. Schnell, and J. B. Rovan (1998). Escher - modeling and performing composed instruments in real-time. In Proc. IEEE Int. Conf. Syst., Man and Cybernetics, San Diego, USA, pp. 1080–4.
Wright, M. and A. Freed (1997). Open Sound Control: A new protocol for communicating with sound synthesizers. In Proc. Int. Comp. Music Conf. (ICMC'97), Thessaloniki, Greece, pp. 101–4.