Nonlinear springs

On the instrumental setup (*page 2*) you will see red arrows labeled *“simulated nonlinear spring”* that marks “a virtual coupling” between real instruments.

PhM Springs are generally used to “couple” physical objects in a bi-directional transmission of energy. When the spring stiffness is low the exciting object will “transmit” energy and generally receive very little in return (“weak coupling”). When stiffness is high objects will interchange energy in a bi-directional fashion as if they morph into a composite object (“strong coupling”). The “nonlinear spring” is a classic stiffness based spring with a controllable nonlinear element where stiffness can be varied as a function of force or speed. This fundamental and apparently simple nonlinear setup (“chaotic pendulum”), has theoretically proven to exhibit a large gamut of behaviours: from gentle “guiding” of energy transmission, to compression / expansion of energy all the way to rich sonic exchanges, including multiple bifurcations, subharmonics and chaotic yet deterministic regimes.

Creating “virtual couplings” between real instruments realised using a COALA system is expected to provide a broad range of situations, from simple alternations to situations where one instrument may create multiphonics sonorities upon another instrument when stiffness modulating between them takes places. Such vast scope requires experiments.

A tentative study of a nonlinear spring (based on a second order differential function) has been implemented in SciLab (a free MatLab like platform) and included for reference (*see pages 6-8 : the nonlinear spring*). It reveals the expected rich and chaotic behaviour. An implementation is desired in gen~ (MaxMSP) and modalys~ (MaxMSP) for realtime interactive use and ModaLisp (LISP) for offline structural use. This requires a numerical solution to the “nonlinear spring” differential equation (see SciLab script). The benefit of implementing in gen~ is twofold. Firstly both gen~ and modalys~ calculates at samplelevel and thus connects well. Secondly the implementation may also serve purposes such as control, mapping, and outputting code to other implementations (eg. VST creation).

Multiphonic simulations

On the instrumental setup (*page 2*) you will see blue double arrows labeled *“simulated multiphonic formular”* that marks another “virtual coupling” of real instruments.

Multiphonics in wind and string instruments concerns the production of multiple audible frequencies from one vibrating object. In 2009 the author simulated a complete model of a bass clarinet including reed, mouthpiece, keys, bell in order to experimentally explore intricate fingerings to a degree not possible in reality. Multiphonics are commonly explained as a nonlinear transfer of energy between dominating modes. However when analysing their phase-space indeed many multiphonics demonstrate the presence of strange attractors revealing a chaotic behaviour.

Application of bifurcation theory to audio-physics is still in its virginal stade why experiments are needed. A tentative study of a virtual coupling based on a force-feedback loop has been realised in ModaLisp (*see vimeo links below*). It shows it can smoothly split (bifurcate) spectres from static tones into multiphonic (subharmonic) like sonorities. In Modalys “gradual couplings” are generally realised using the ”*weight parameter”* (weighting a connection). As it is not a physical parameter a search for other functions providing graduation of weak and strong interactions is needed. Thus a development / implementation of numerical solutions of other nonlinear functions is desired, such as: *Duffing*, *Van de Pol oscillator, Chua’s circuit*, *Lorentz functions* all aimed for implementation in both Gen~, modalys~ and ModaLisp.

Non-Linear Feedback Tube
https://vimeo.com/214278374
https://vimeo.com/214278476

Instruments as speakers

Traditional cabinet speakers have be replaced by instruments acting as their own speaker membranes. Sonic output is transmitted to instruments such as cymbals, drumskin, soundboard each with their own nonlinear characteristics (fx the softer the more resonant, the louder the more nonlinear). The 3 played instruments will each be equipped with a COALA system, and 2 additional cymbals with full range transducers from Clarke Synthesis. This latter idea has been documented in an experimental setup that needs further refinement as its output is overly loud that easily masks other sources (*see vimeo links below*). Miniature cymbals-speakers may also be added for handheld spatial opperation.

Non-Linear Chinese Cymbal
https://vimeo.com/214275022
https://vimeo.com/214276106

Simulation versus real

The project will include a discussion of the aesthetic value of imitation of physical mechanisms projected as a structural part of musical composition. The instrumental setup, the nonlinear couplings therein, the sonic projection all shows an aesthetic bias towards a “physical” approach to composition. It is during interaction that the non-linearity shows its attractive quality in rich, possibly chaotic, yet deterministic and thus controllable behaviour. Since nonlinearity by nature is hard to predict a compositional sketch is best created in direct experimentation with the instrumental setup.

Why simulate? Well, as Claude Cadoz puts it:
“Simulate to understand / understand to simulate” (it is after all much like the egg and the hen) ! *

Hans Peter Stubbe Teglbjærg, 17. november 2017

** Claude Cadoz “Simuler pour connaitre / Connaıtre pour simuler”.*
Colloque Modèles physiques, 1990, Grenoble, France. Vol. III, pp.663-707, 1994. <hal-01022518>.