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hem Haute école de musique Genève - Neuchâtel

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

ENS ÉCOLE NORMALE SUPÉRIEURE

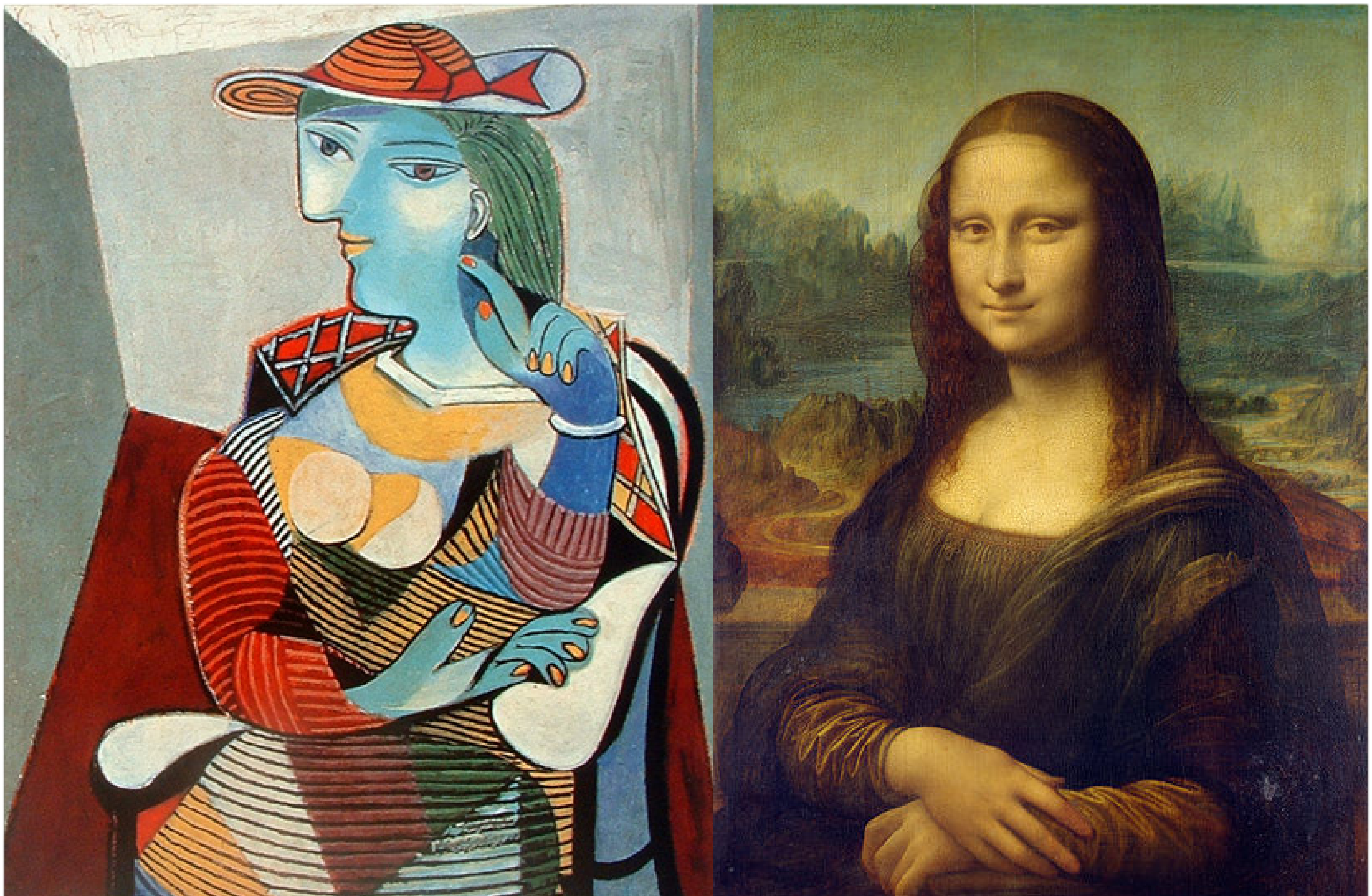
CARMINE-EMANUELE CELLA

PLAYING THE WORLD

AN INTRODUCTION TO PHYSICAL MODELLING FOR AUGMENTED REALITY

UC BERKELEY - MUSIC 159 - GUEST LECTURE #4

KATHARSIS AND MIMESIS



FROM PHYSICAL MODELLING TO PHYSICALLY-INSPIRED

Physical modelling synthesis ⟷ **Physically-inspired synthesis**

Accurate

Real sounds (almost)

Expressive

Plausible sounds

PHYSICAL MODELLING

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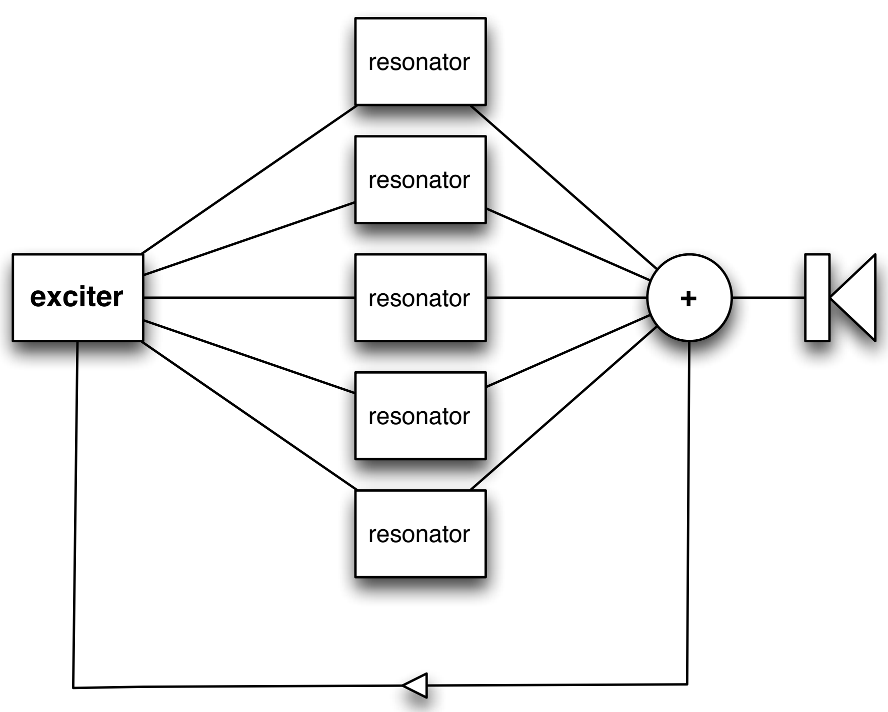

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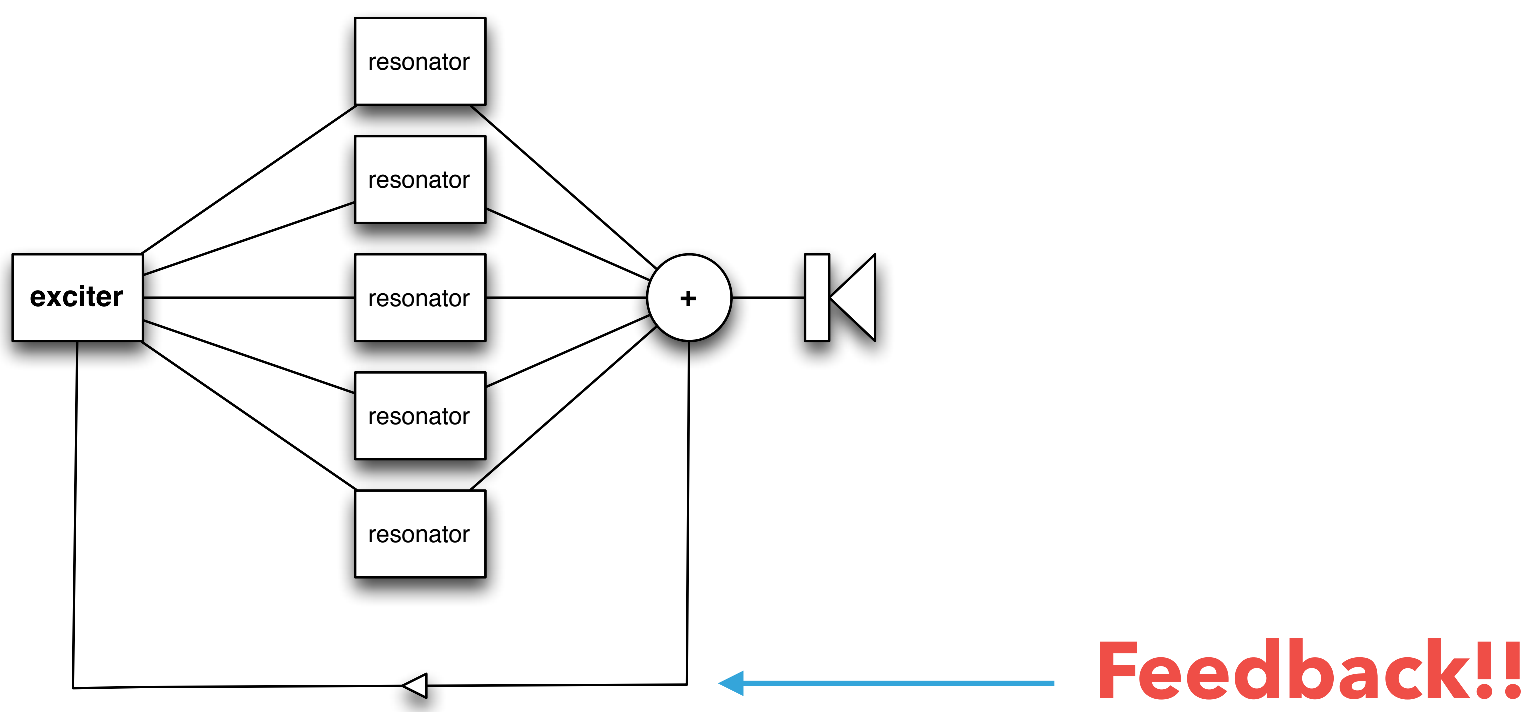

HISTORICAL PERSPECTIVE

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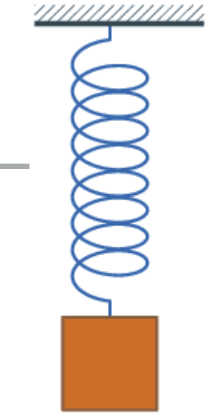
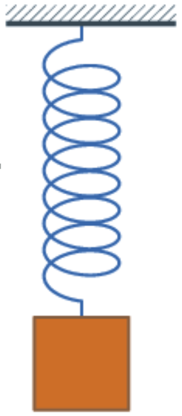
- Waveguides (1990/2000, Smith): two delay lines with taps and various filters
- **Modal synthesis** (1990/2010, Adrien): resonant filters and modal weights



MODES OF VIBRATION

- A vibrating object can be represented by the spring-mass system:

$$x = e^{-\alpha t} A cos(\omega_d t + \phi) \tag{1}$$



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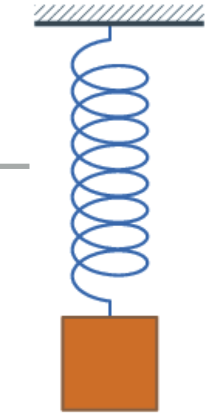

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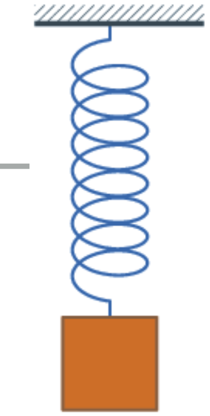

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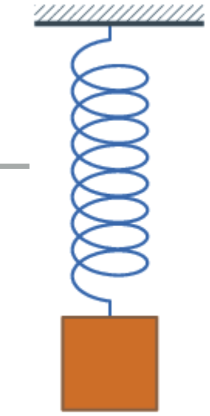

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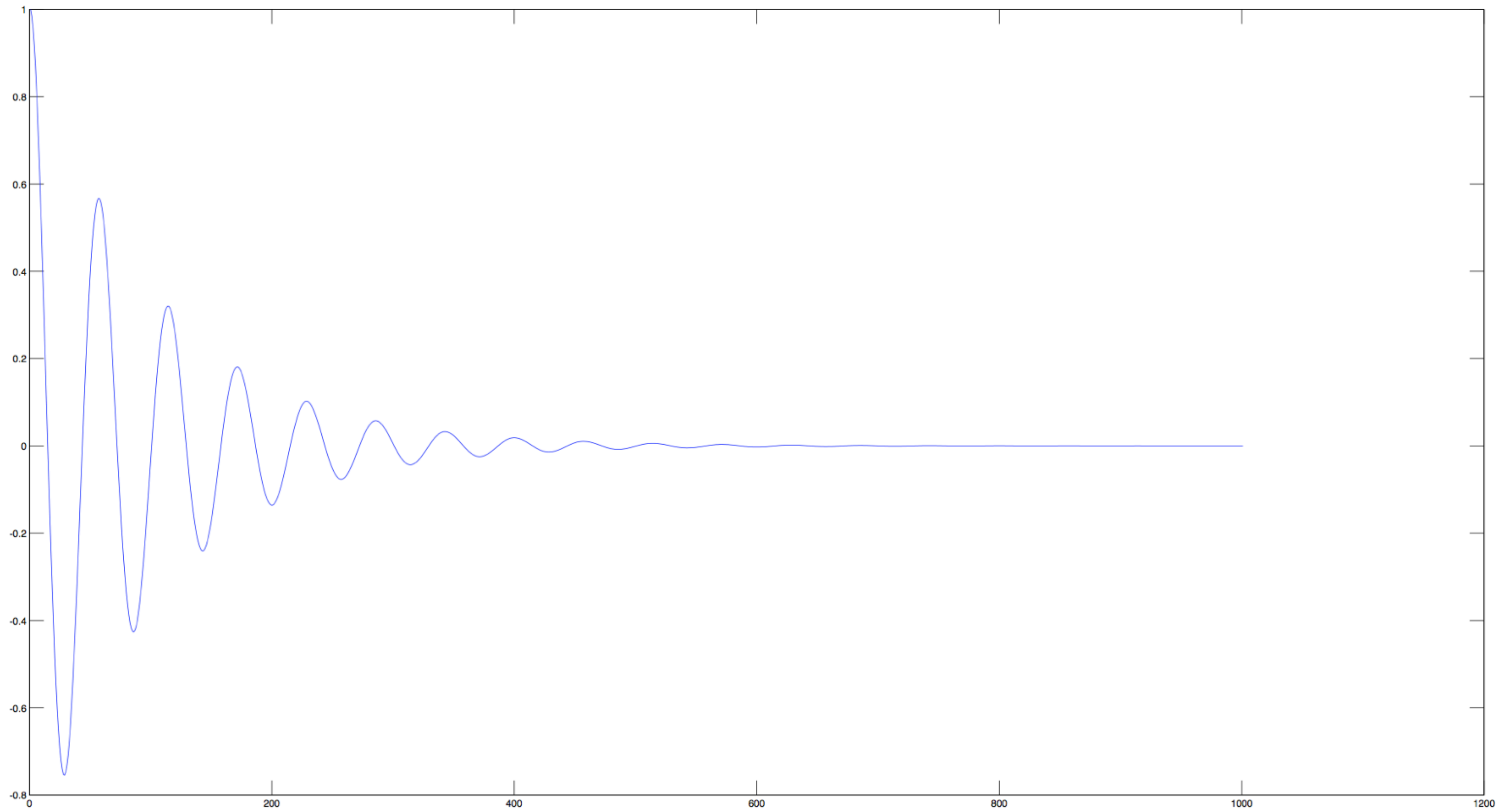
- A and ϕ are, respectively, the amplitude and the phase of the vibration and are determined by initial displacement and velocity

MODES OF VIBRATION

A natural mode of vibration, as described by equation 1

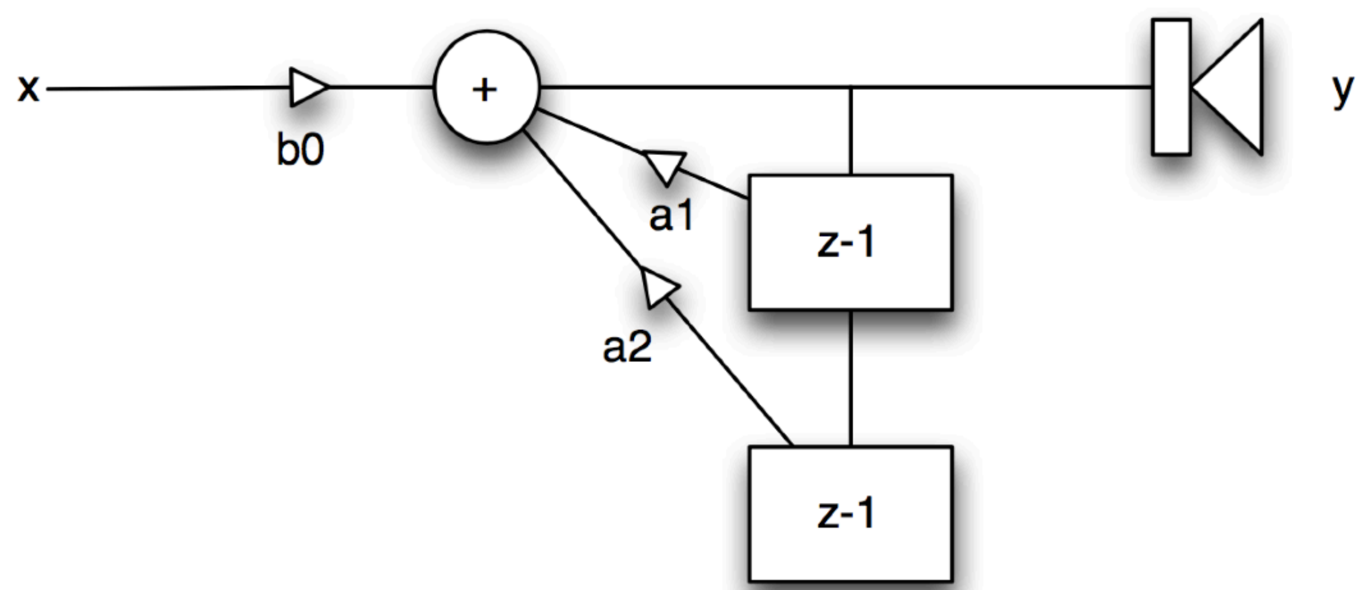


MODES AND FILTERS

In digital domain, equation 1 can be reproduced by the following second-order differential equation (two-poles):

$$y = x \cdot b_0 - y \cdot z^{-1} \cdot a_1 - y \cdot z^{-2} \cdot a_2 \tag{2}$$

where Z^{-n} is the delay of n digital samples, b_0, a_1 and a_2 are *coefficients* and x is the input signal



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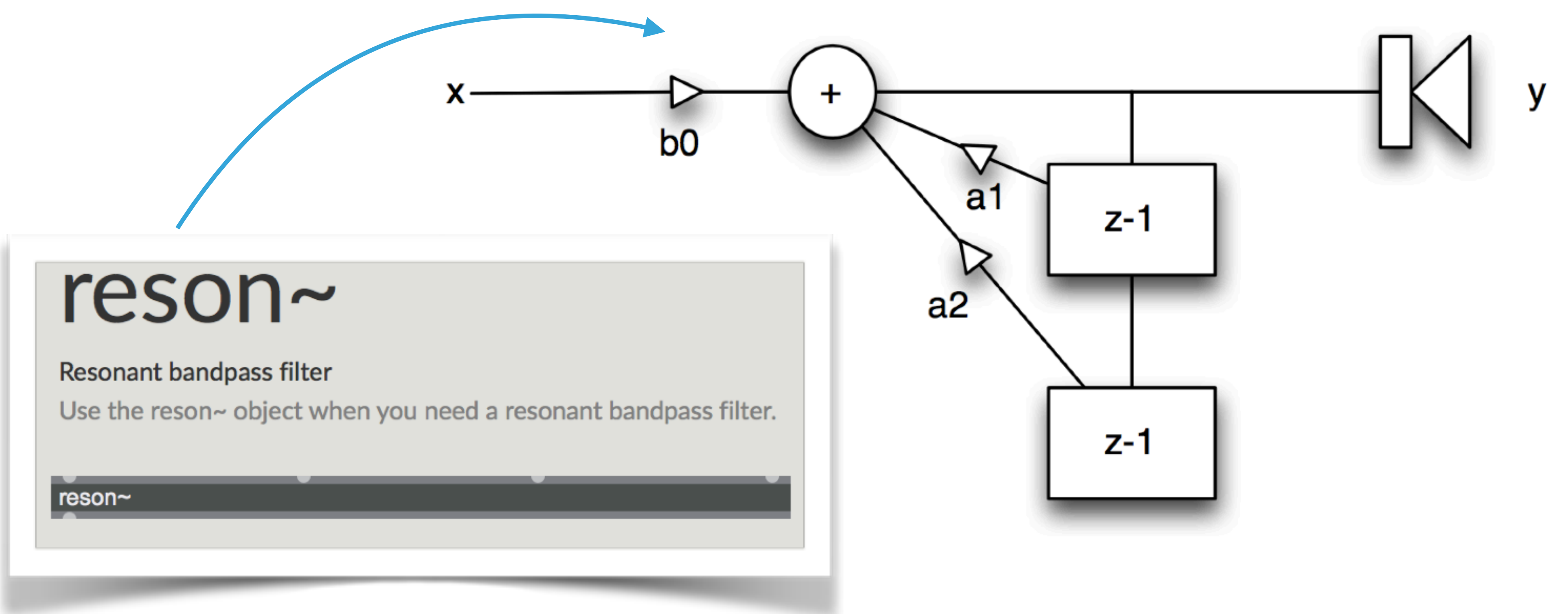

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Feedback = timbre!!

A CREATIVE APPROACH

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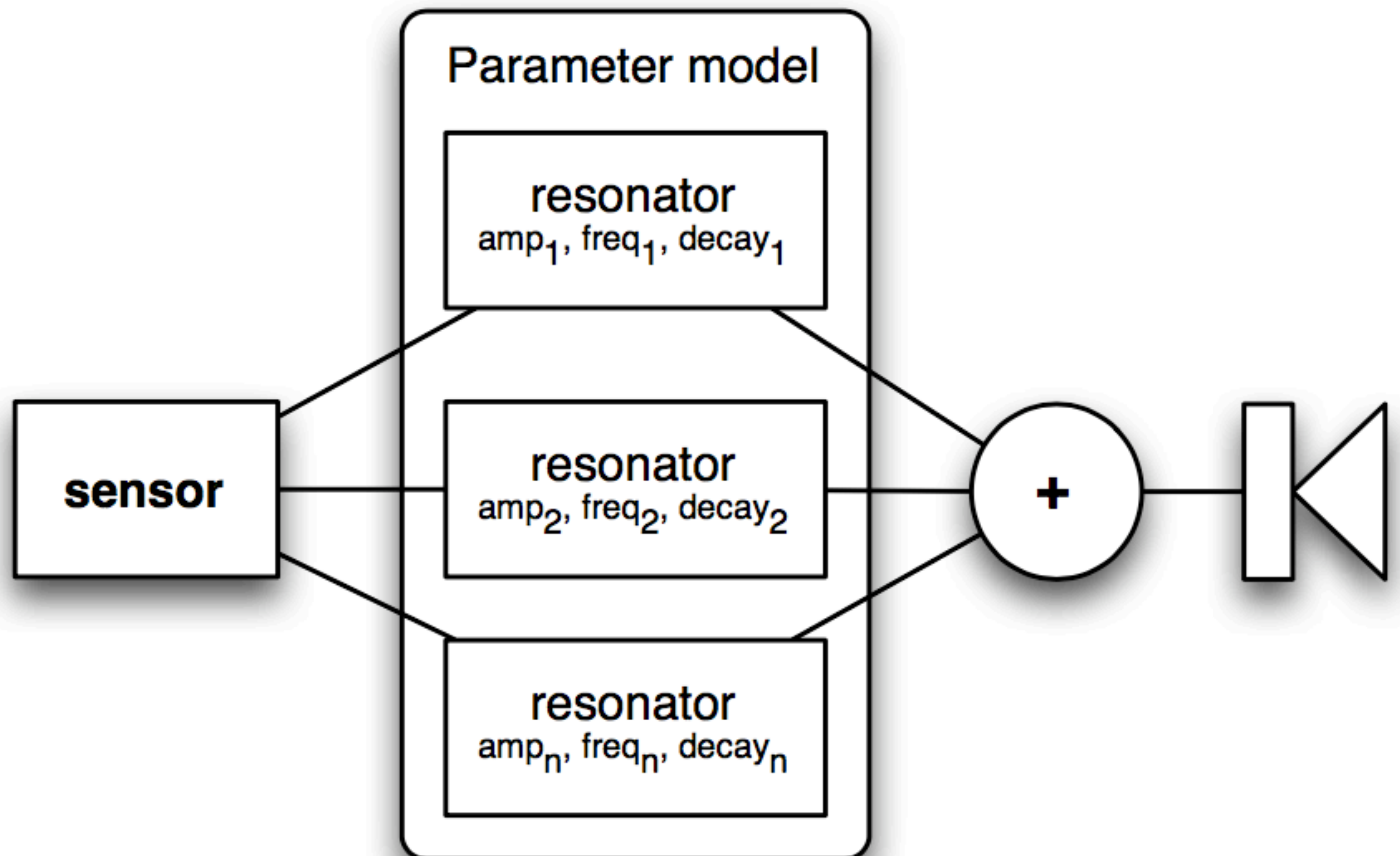
- The simulation of a real vibrating object by means of modal synthesis (for example a musical instrument) can be a difficult task
- The simulation of *quasi*-physical instruments can be an interesting creative activity
- **Physically-inspired** synthesis is variant of modal synthesis that generates sounds with special *physical* characteristics without modelling real vibrating objects

PARAMETER MODELS

In physically-inspired synthesis, the feedback between the exciter and the resonators is replaced by a **parameter model** and the excitation is provided by a **sensor**



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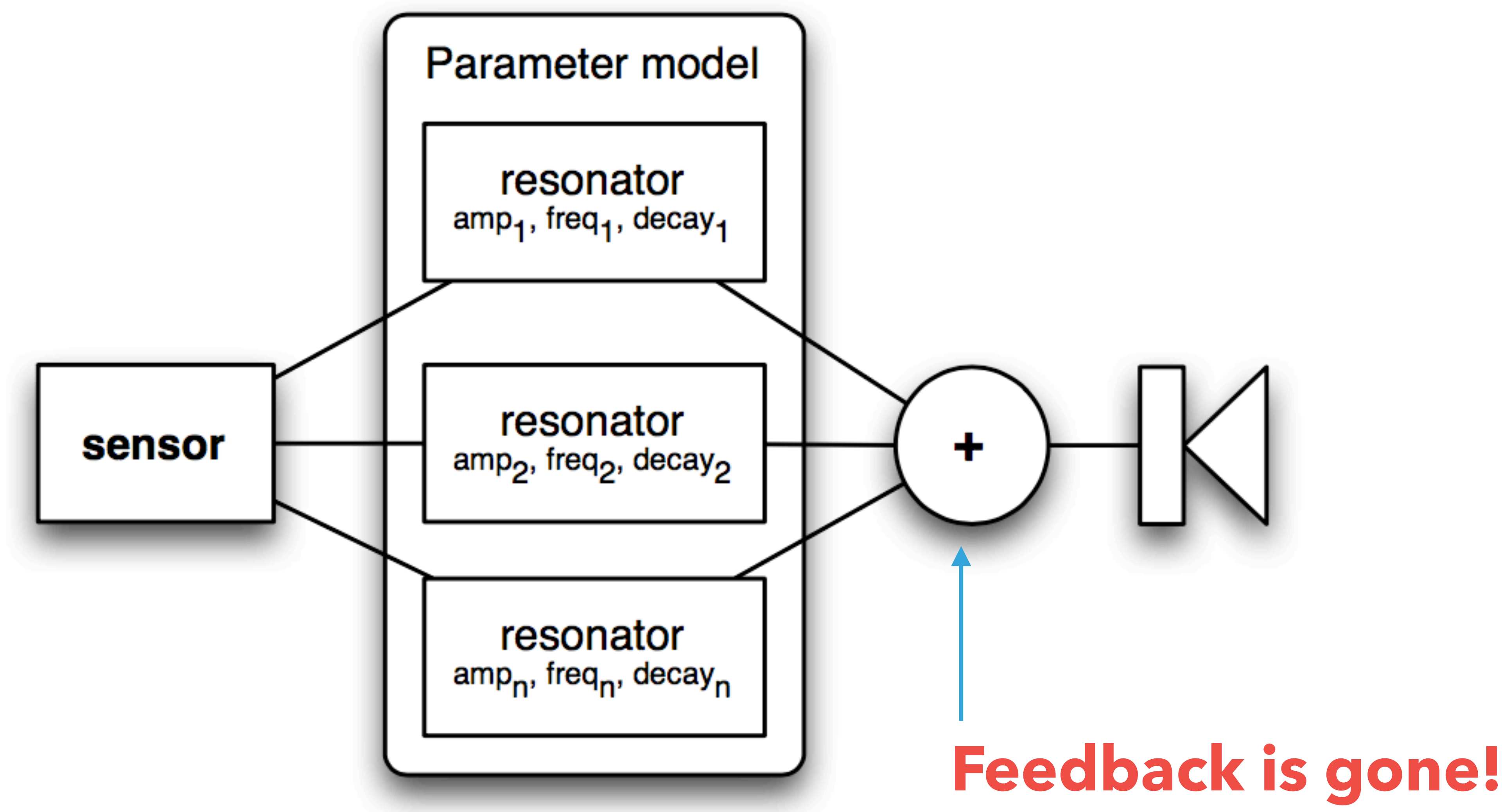

GENERALISED SPECTRAL MODELING

Our model will use a generalised series (harmonic + geometric) for the parameters of each mode, where each variable is connected to a physical property:

$$\sum_{n=1}^{\infty} \frac{1}{n^{\alpha} \cdot \beta^{n} + \gamma}$$

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size

CALCULATION OF PARAMETERS

We will split previous series in two parts; one will be used for frequencies and the other for decays:

$$\sum_{n=1}^{\infty} \frac{1}{n^{\alpha}}$$

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$$f_n = f_0 \cdot n^{\alpha}$$

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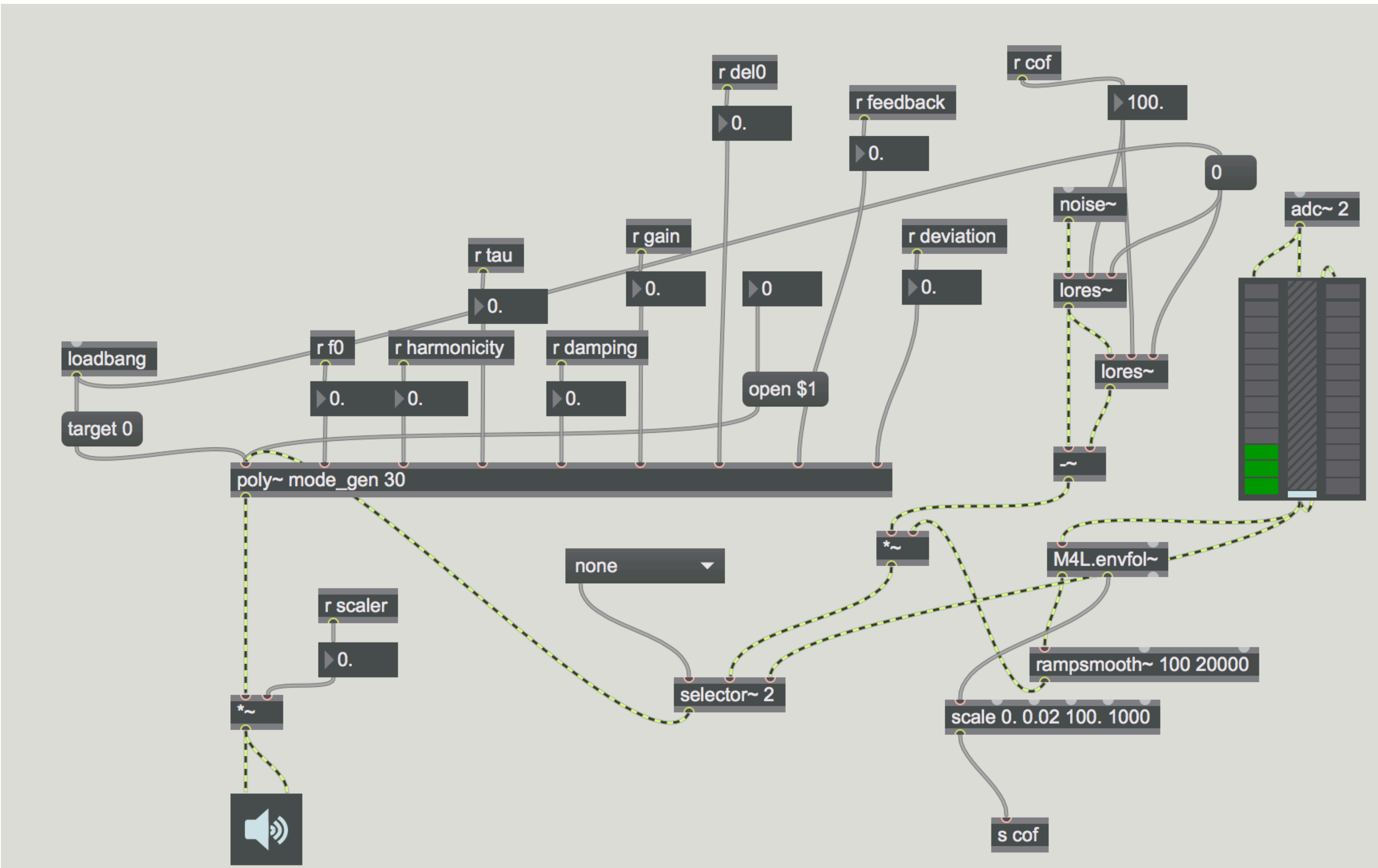
$$\tau_n = \tau_0 / \beta^n$$

LET'S GO LIVE!


r del0
r cof
r feedback
100.
0.
0.
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noise~
adc~ 2
r gain
r deviation
r tau
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0.
lores~
0.
loadbang
r f0
r harmonicity
r damping
lores~
open $1
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none
r scaler
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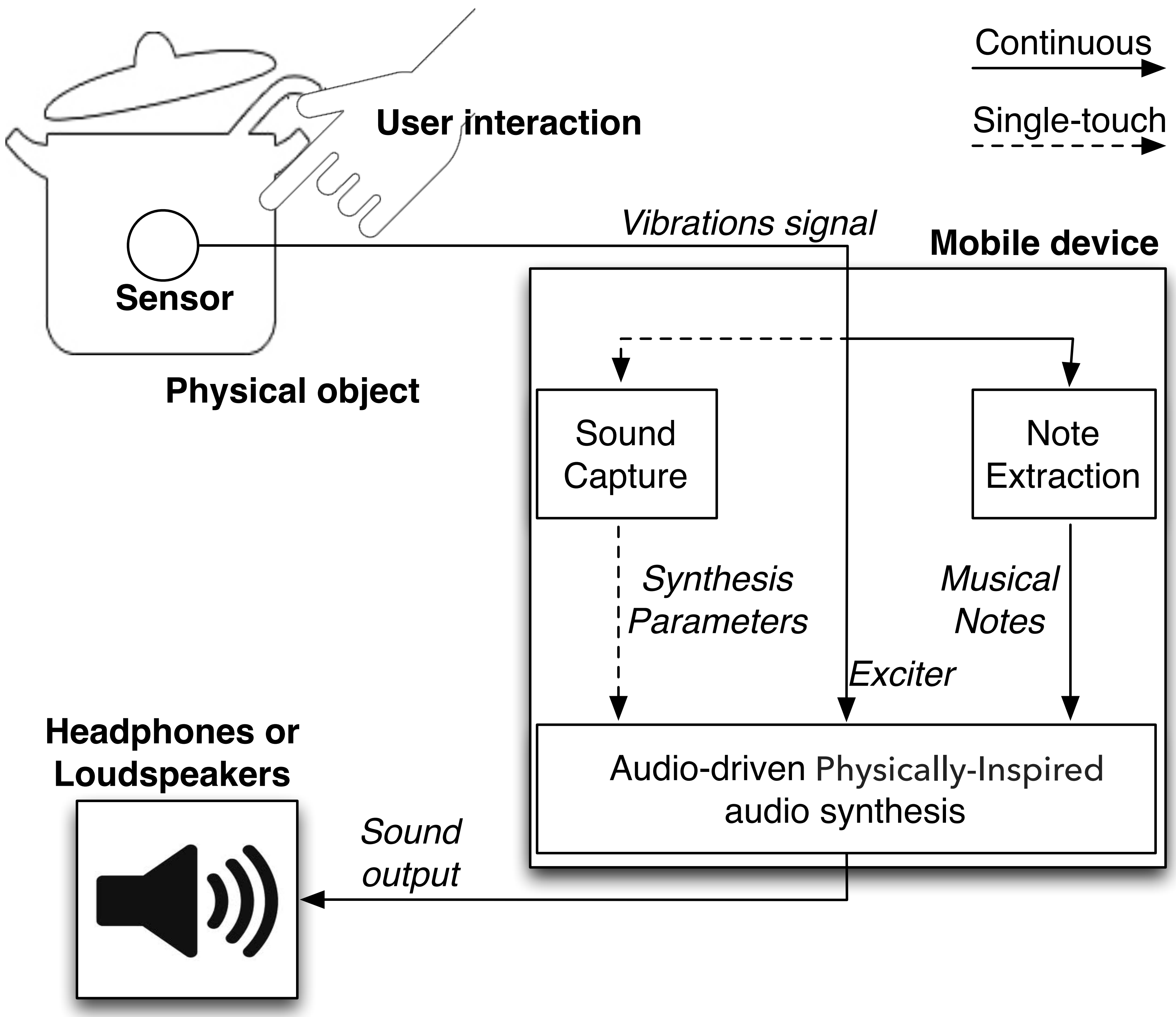
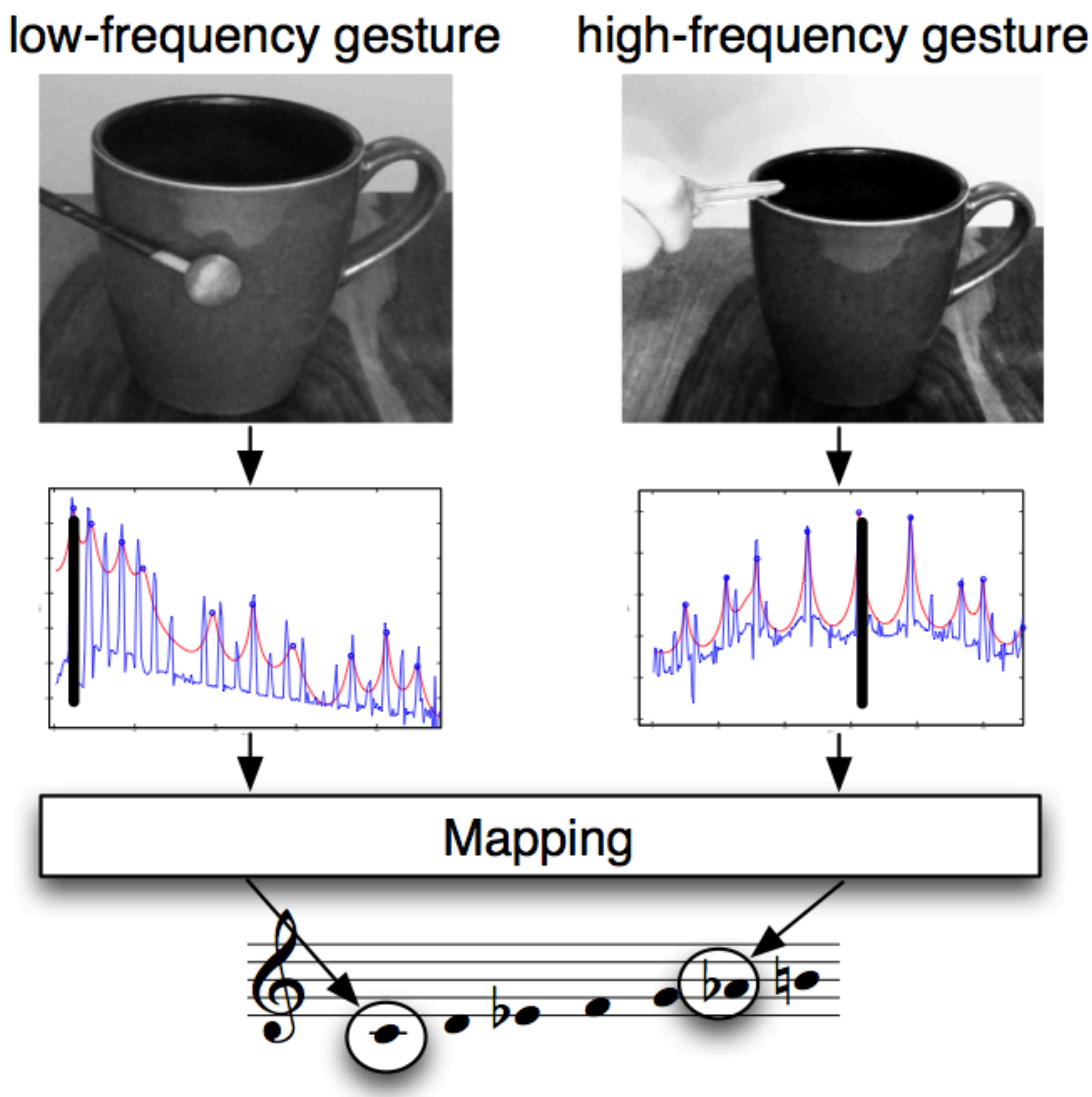
selector~ 2
scale 0. 0.02 100. 1000
s cof

CAN WE SONIFY THE WORLD?

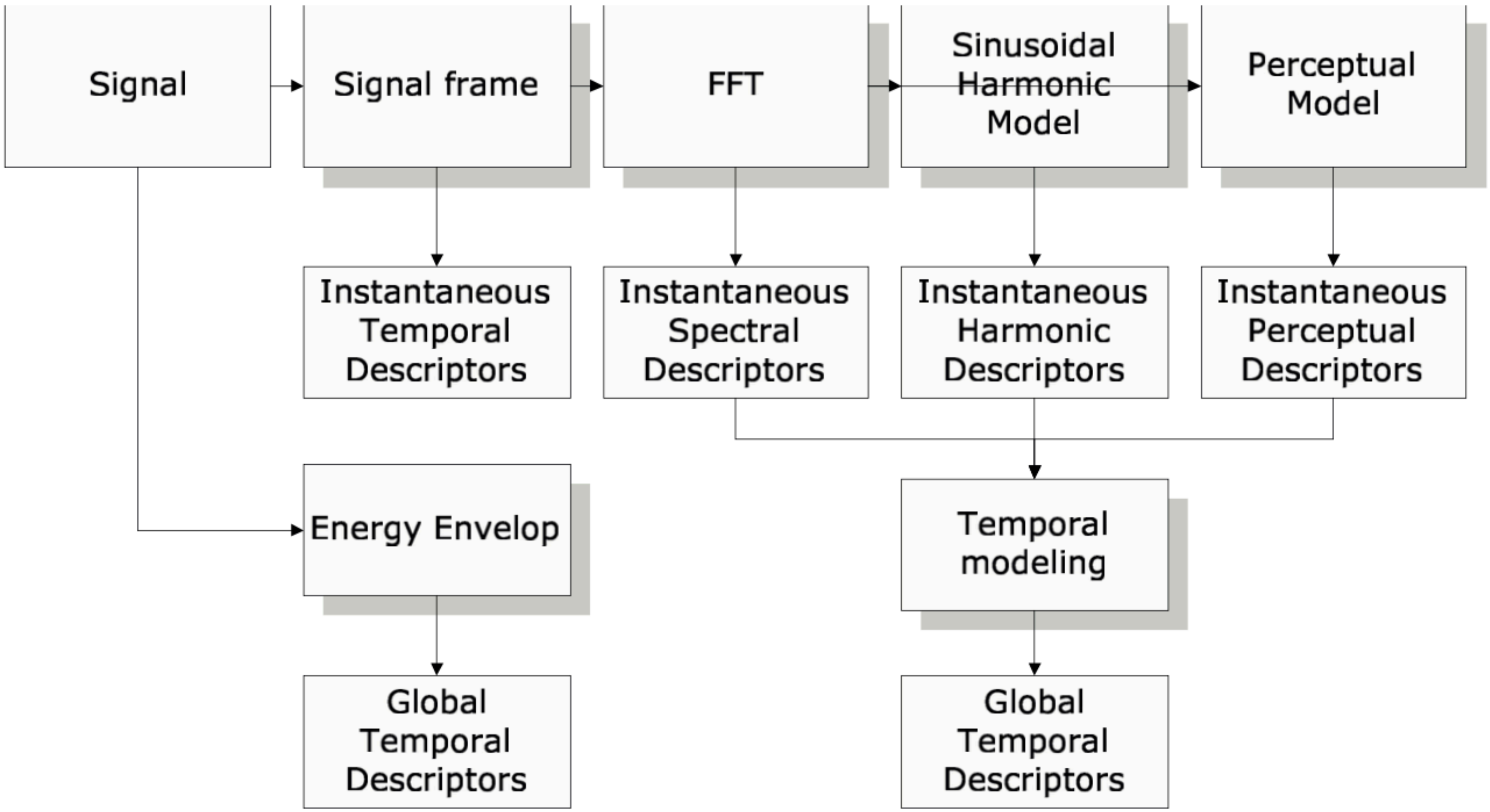


GESTURE MAPPING



LOW-LEVEL FEATURES FOR GESTURES

Numerical values describing the contents of a signal according to different kinds of inspection: *temporal*, *spectral*, *perceptual*, etc.



SPECTRAL FEATURES

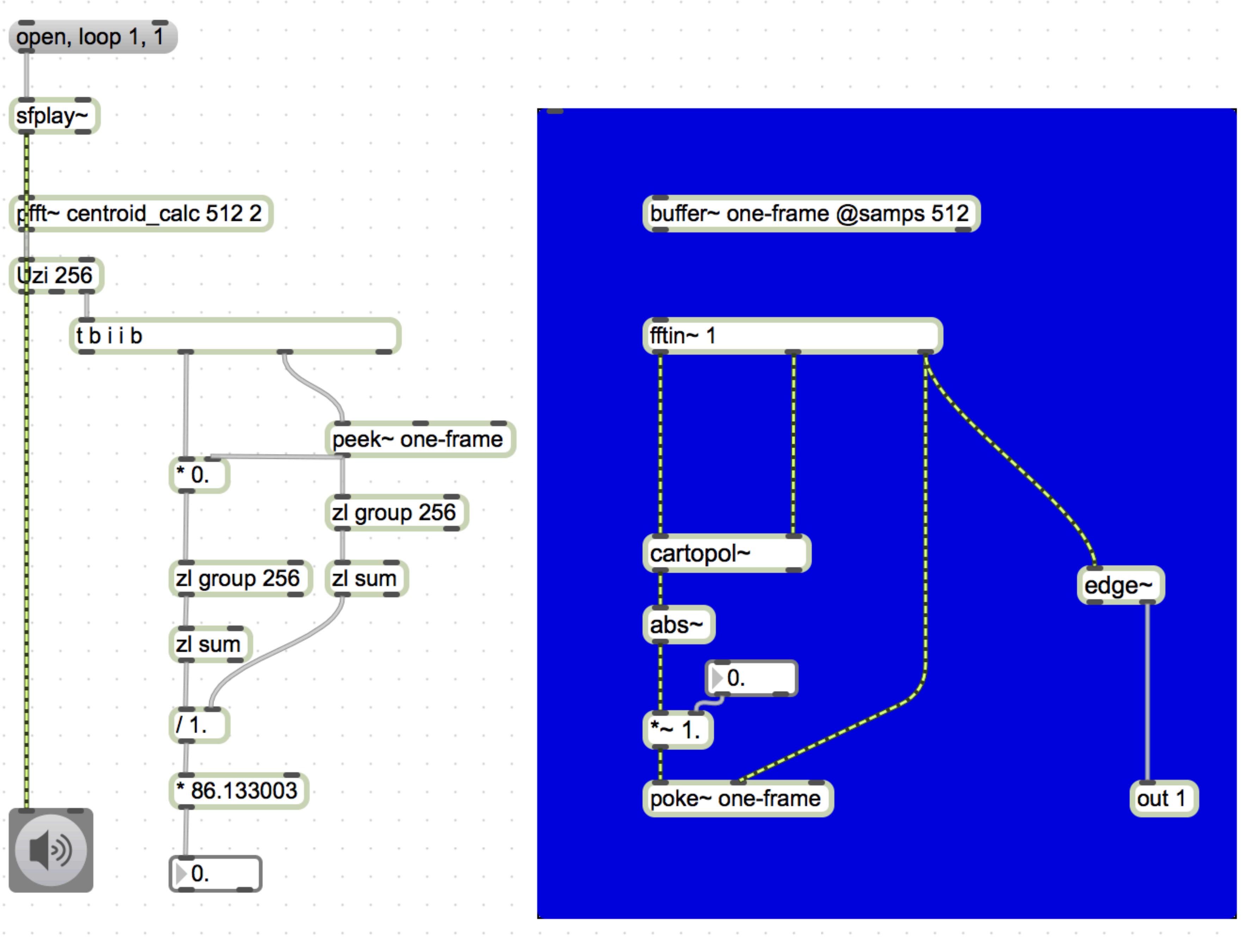
Spectral centroid (brightness) and spectral spread (bandwidth) are important features:

$$\mu = \int x \cdot p(x) dx.$$

$$\sigma^2 = \int (x - \mu)^2 \cdot p(x) dx.$$

Where *x* are the observed data (frequencies of the spectrum) and *p(x)* are the probabilities of observations (amplitudes of the spectrum)

LET'S GO LIVE AGAIN!



MOGEES

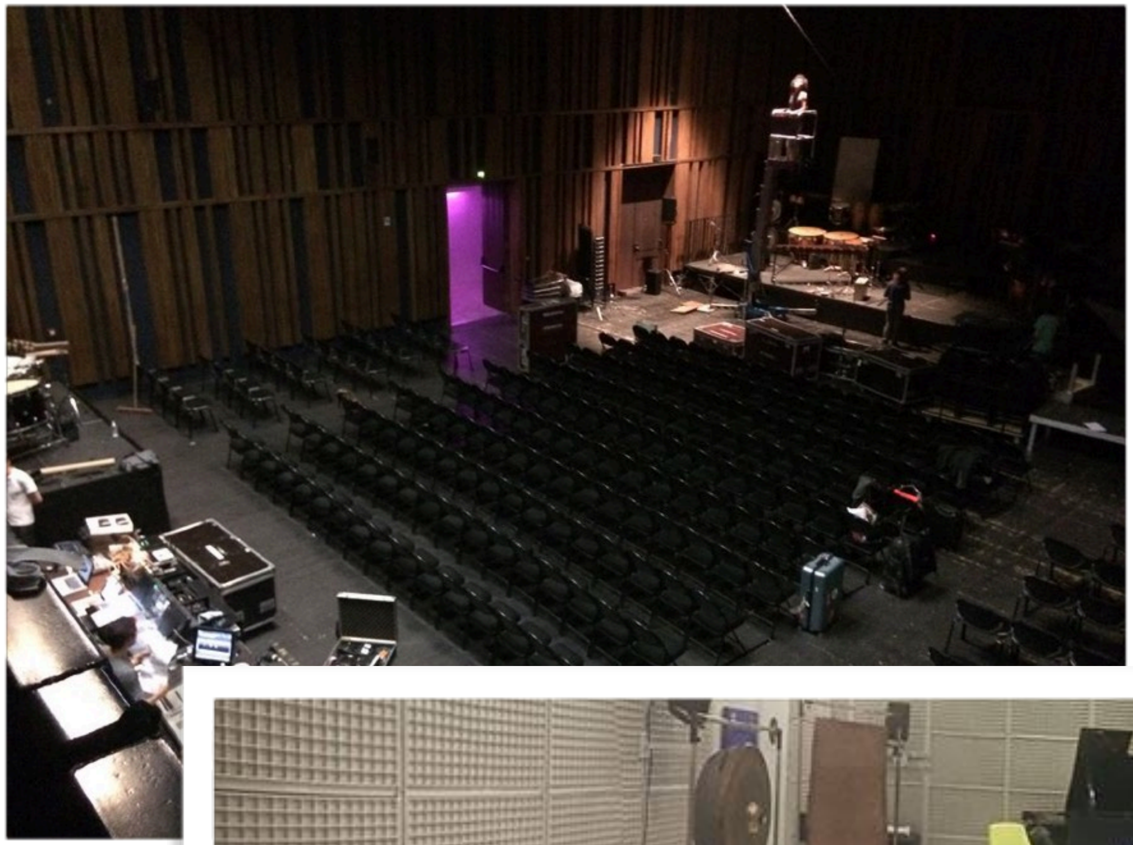

"Mogees' software makes music magic!"
USA TODAY
MOGEESPRO
Turn a tree into a harp.
Turn a table into a drumkit.
Turn a chair into a MIDI controller.
Mogees Pro gives you an entire world of new creative possibilities.
amazon buy now
Visit Store
The Apps
MOGEES
Transform anything into a musical instrument
Quick start guide
Software download and registration codes
Flight case
Mogees vibration sensor
2 re-washable adhesive pads
3.5mm TRRS to 6.5mm TS jack adapter

INSIDE-OUT

for smart percussions (2017)

commissioned by Ircam and Percussions de Strasbourg

first performance: june 2017, Paris



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SUMMARY

- Modelling reality means choosing an *abstraction* level (mimesis and katharsis)
- Physical modelling synthesis is a flexible framework to model the acoustic behaviours of physical objects
- Physically-inspired synthesis expands this possibility by creating *plausible sounds* by means of sensors and parameter models
- Gesture recognition, by means of low-level features, is the key step to create a system for **augmented reality**

GITHUB REPOSITORY OF THIS LECTURE

https://github.com/CarmineCella/Berkeley2018

SELECTED REFERENCES

- C. E. Cella, Generalized series for spectral design, 2013
- C. E. Cella, On physically-inspired synthesis of sound, 2012
- C. E. Cella, On symbolic representations of music, 2011

ANY QUESTIONS?

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