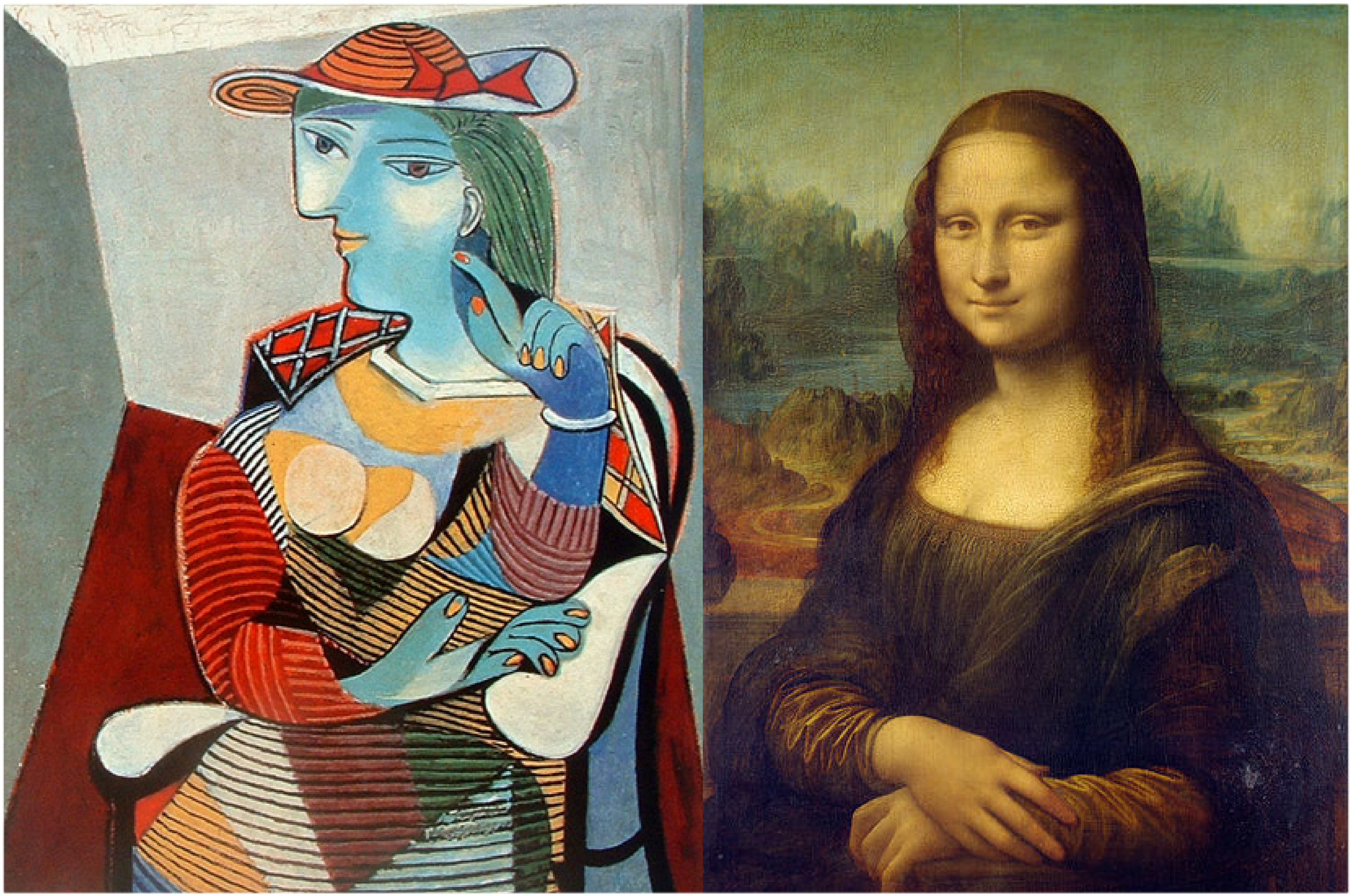
CARMINE-EMANUELE CELLA

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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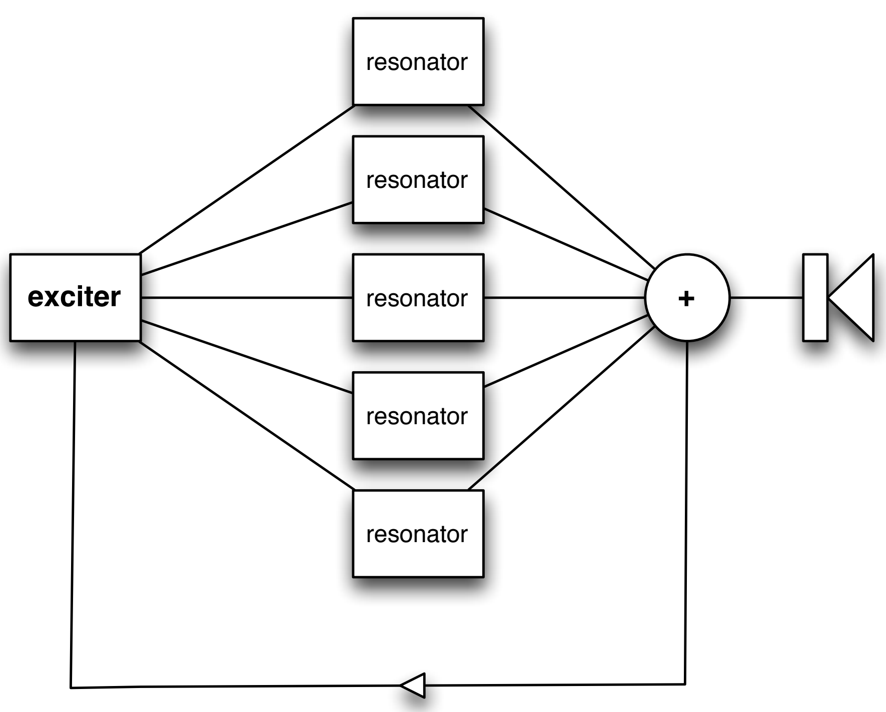

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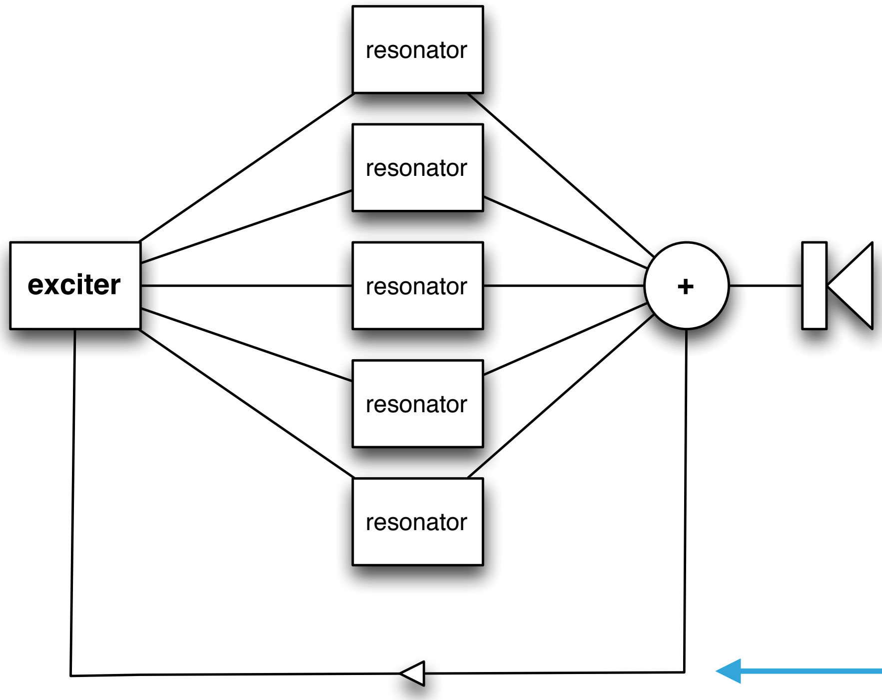
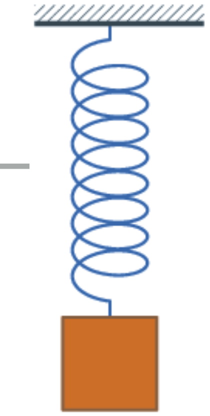


Feedback!!

HISTORICAL PERSPECTIVE

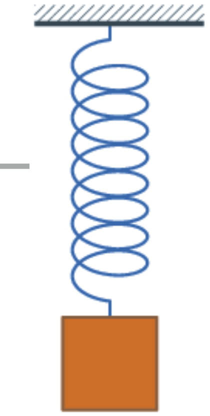
- Karplus-Strong (1983): delay-line + lowpass filter
- Smith-Karplus-Strong (1983): delay-line + lowpass filter + allpass filter
- Waveguides (1990/2000, Smith): two delay lines with taps and various filters
- **Modal synthesis** (1990/2010, Adrien): resonant filters and modal weights



MODES OF VIBRATION

- A vibrating object can be described by the *harmonic oscillator,* that can be represented by the spring-mass system:

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



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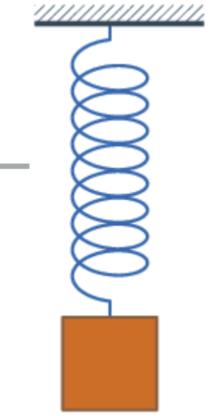

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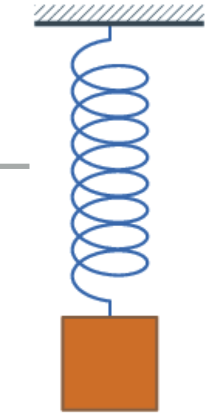

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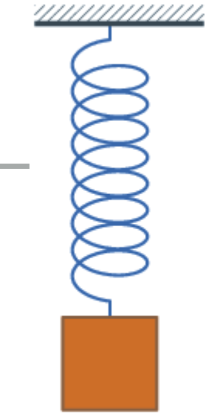

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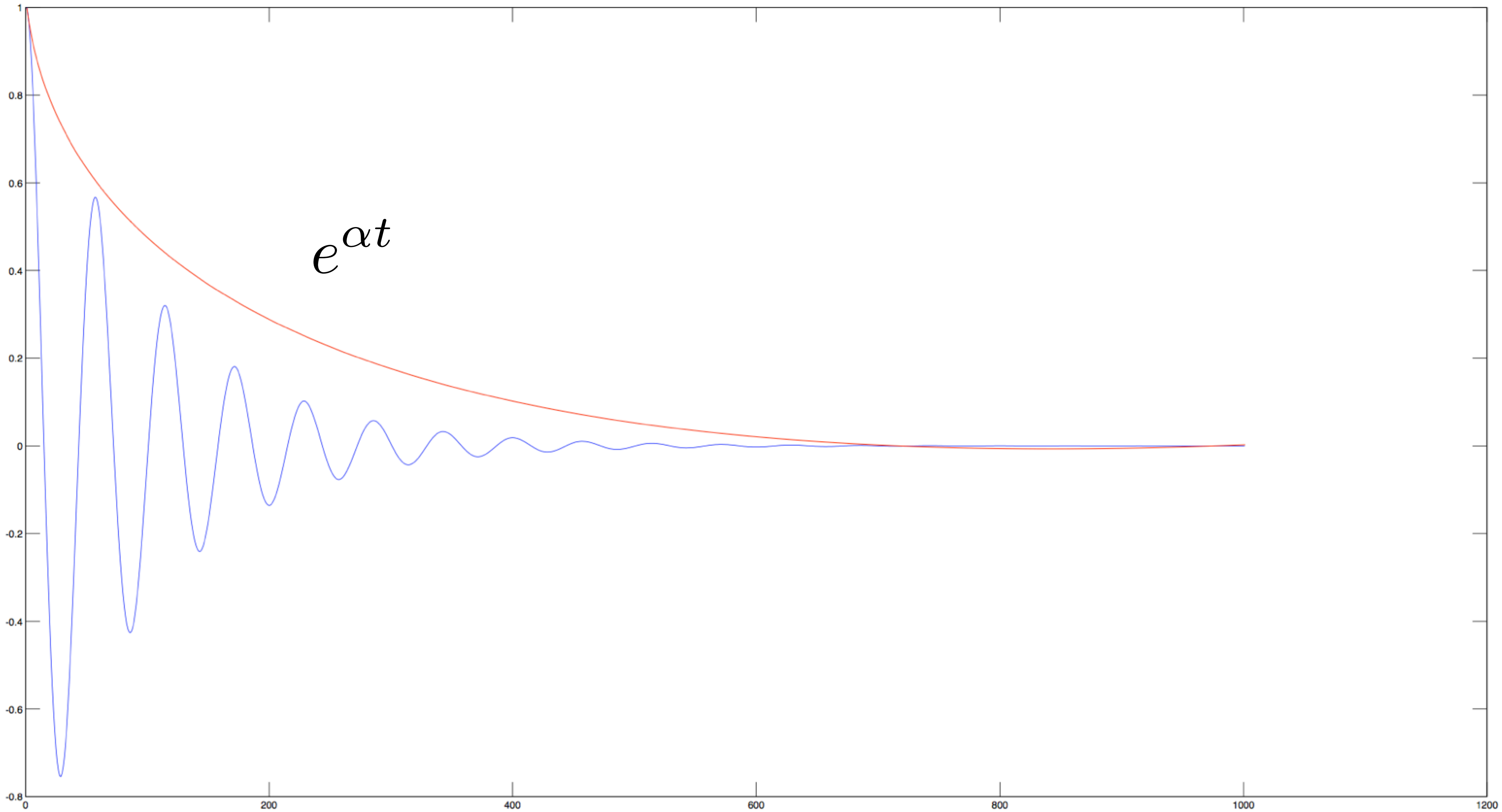
- A and ϕ are, respectively, the amplitude and the phase of the vibration and are determined by initial displacement and velocity

MODES OF VIBRATION

A natural mode of vibration, as described by equation 1

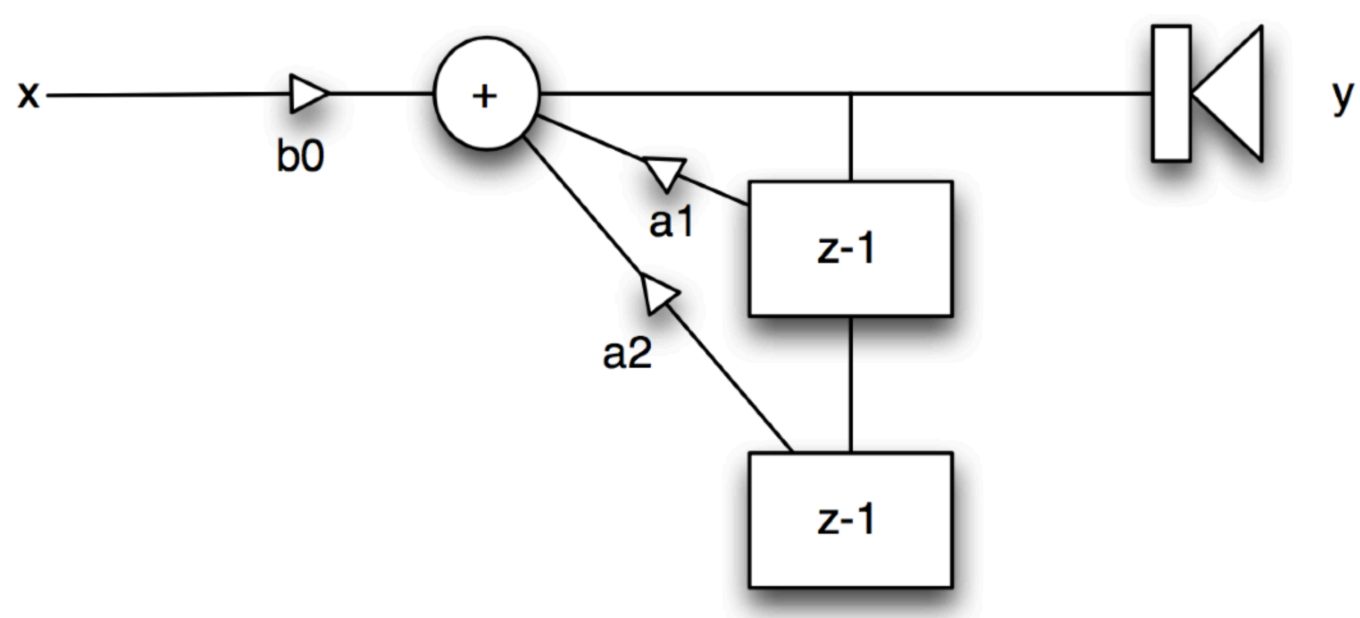


MODES AND FILTERS

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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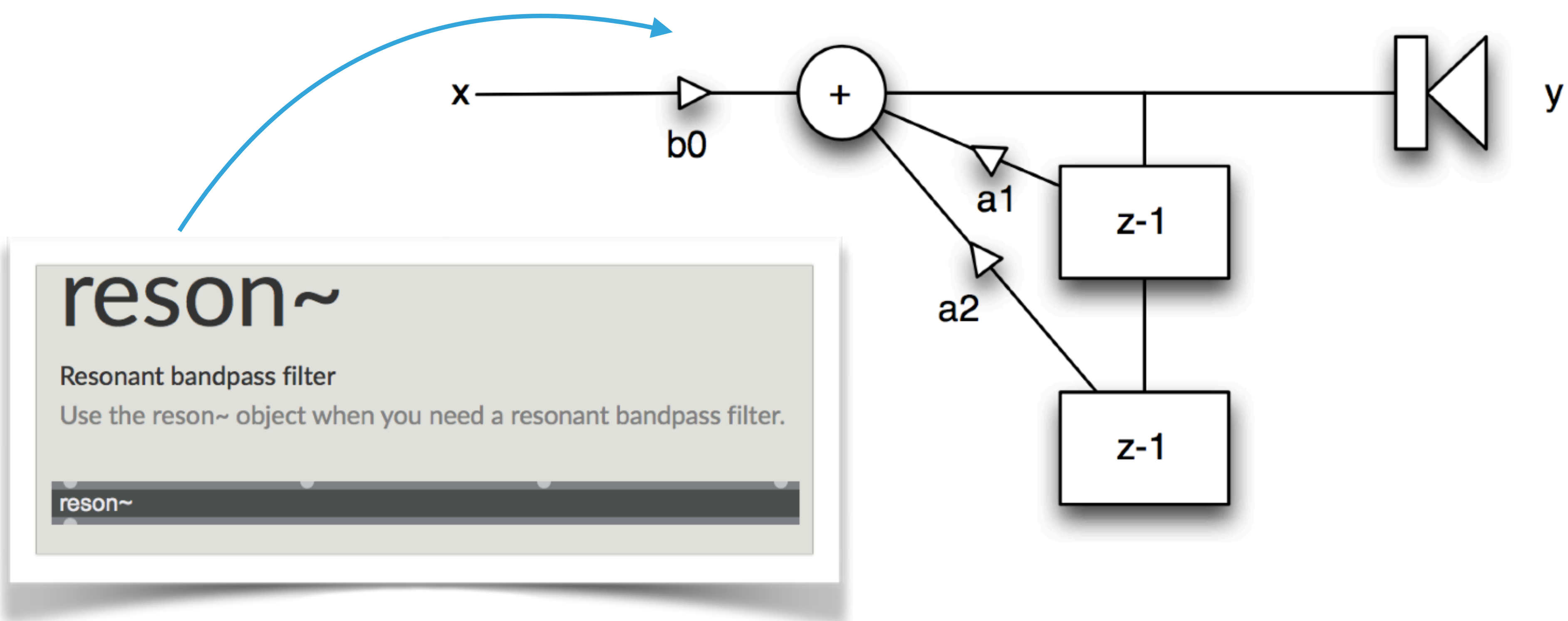

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Feedback = timbre!!

A CREATIVE APPROACH

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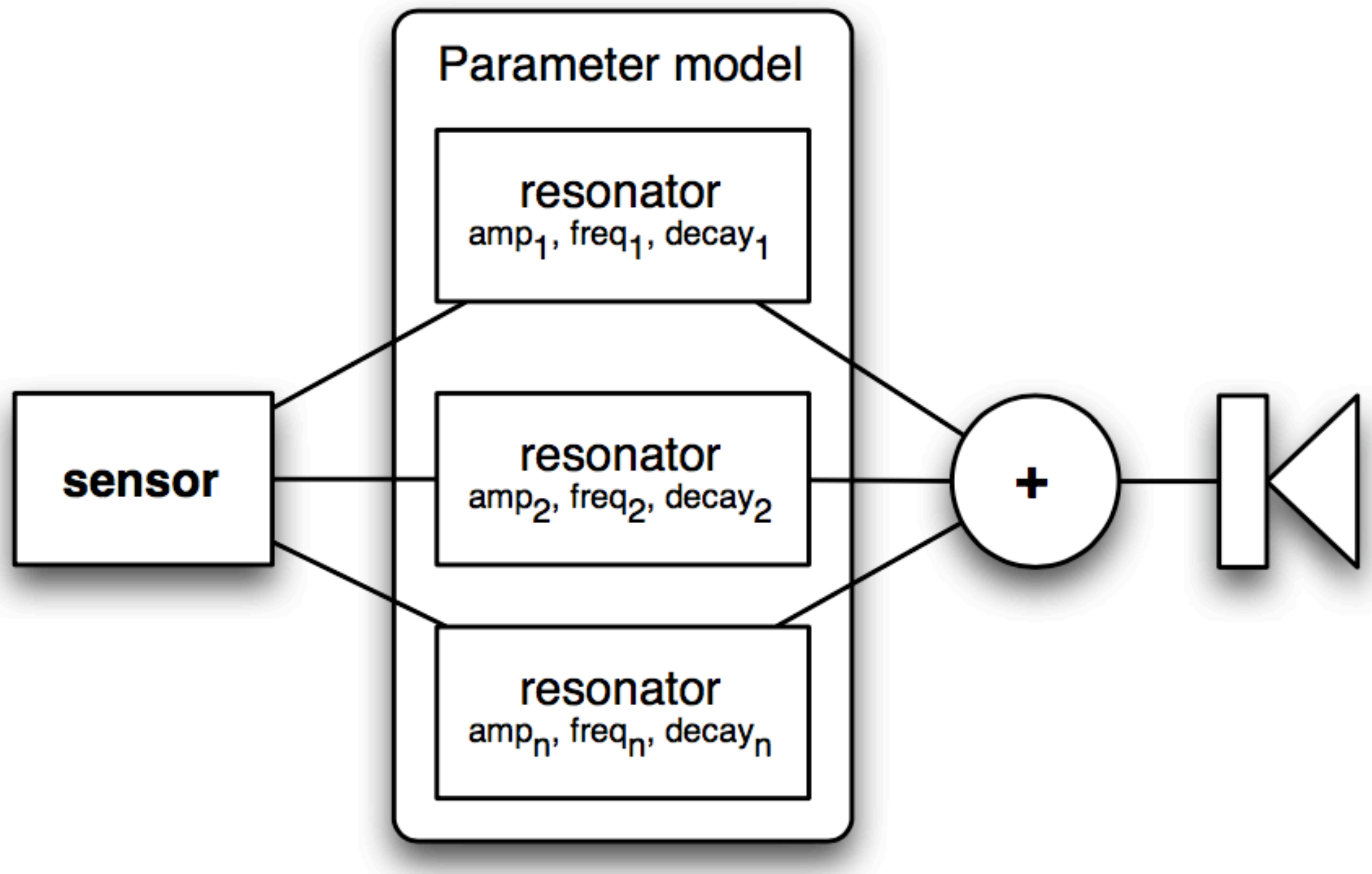
- The simulation of *quasi*-physical instruments can be an interesting creative activity
- **Physically-inspired** synthesis is variant of modal synthesis that generates sounds with special *physical* characteristics without modelling real vibrating objects

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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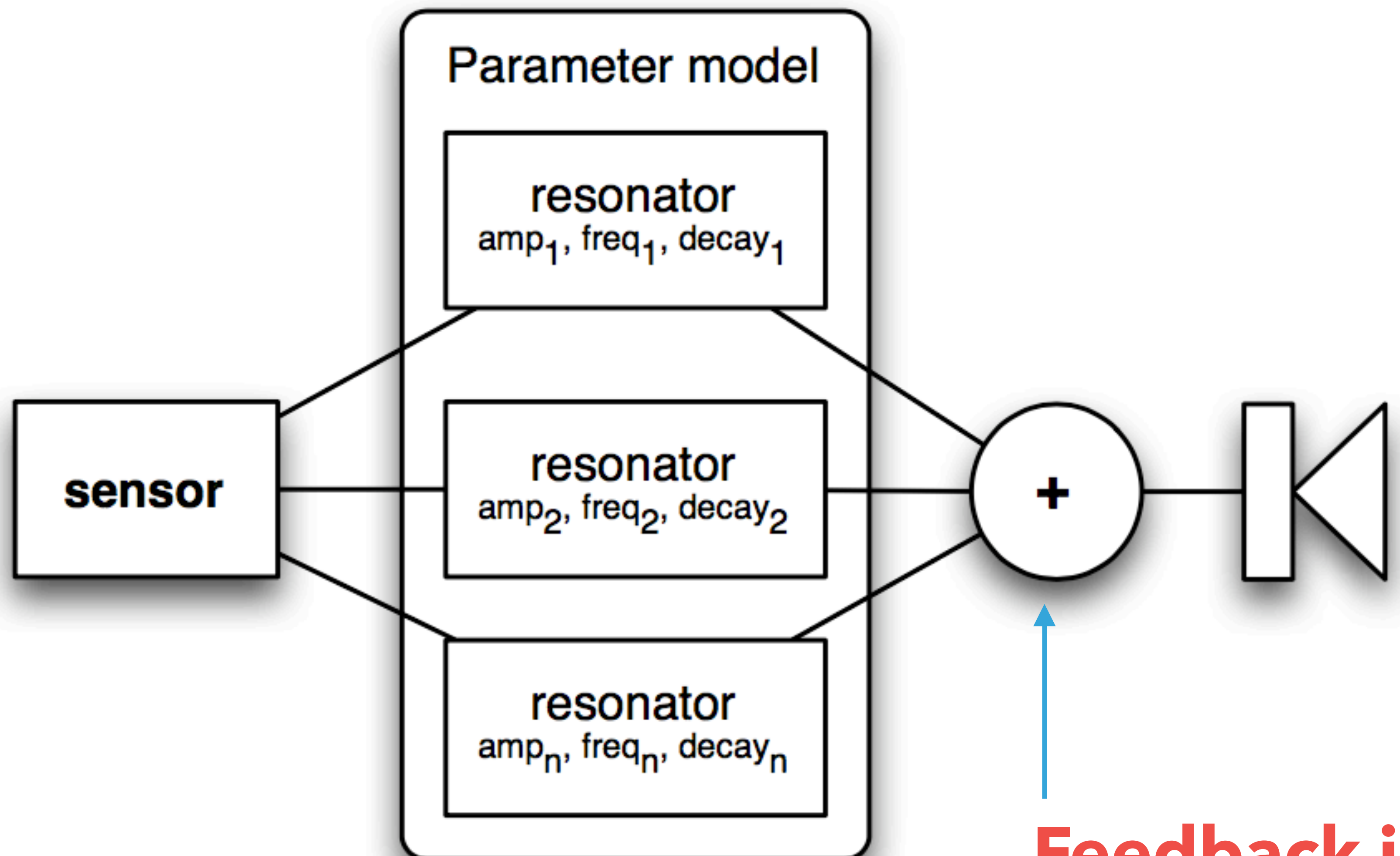

Feedback is gone!

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:

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mode number

size

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CALCULATION OF PARAMETERS

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

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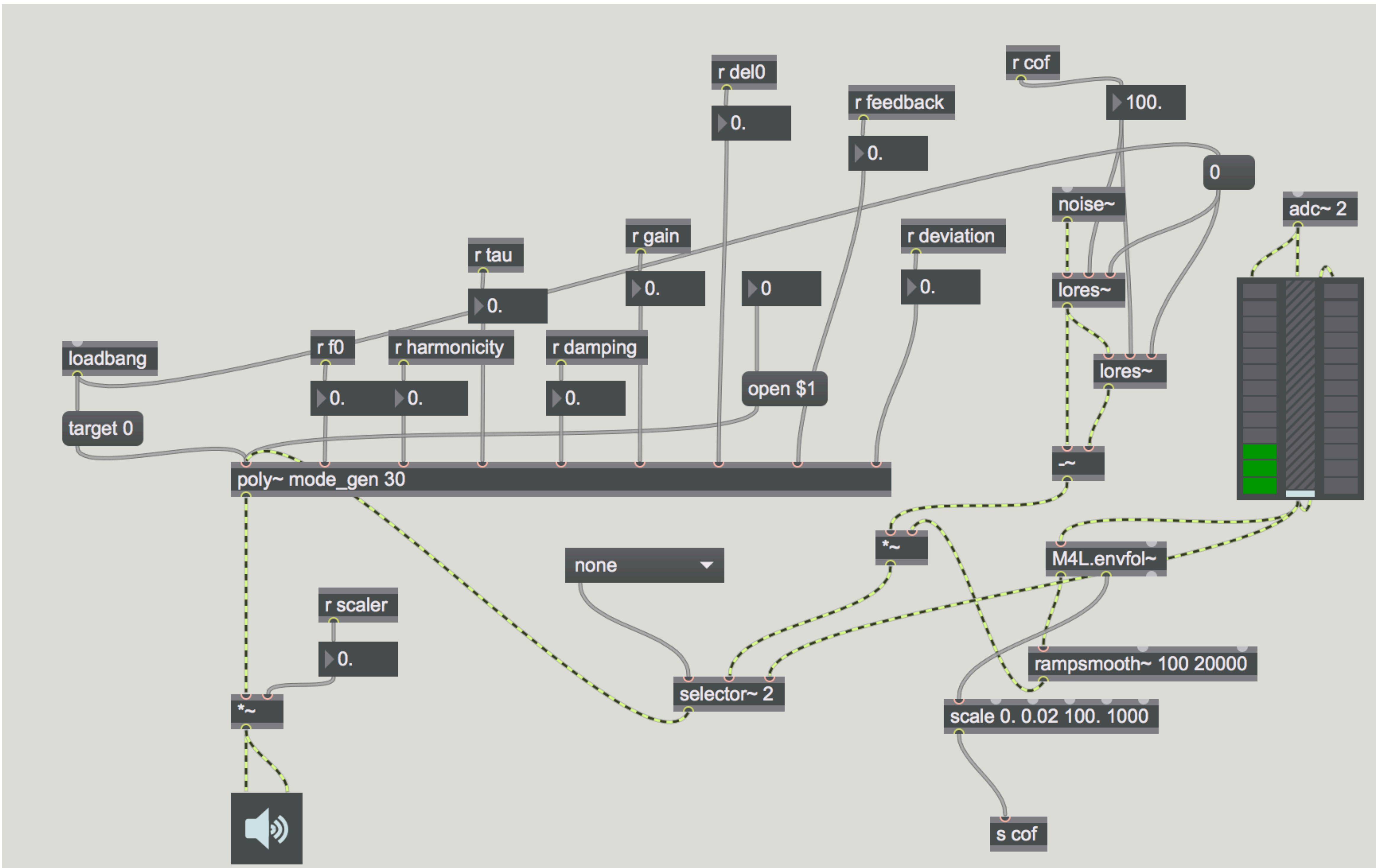
$$\tau_n = \tau_0 / \beta^{n}$$

LET'S GO LIVE!


r del0
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r feedback
0.
r cof
100.
0
noise~
adc~ 2
r deviation
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r gain
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r tau
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lores~
lores~
loadbang
r f0
r harmonicity
r damping
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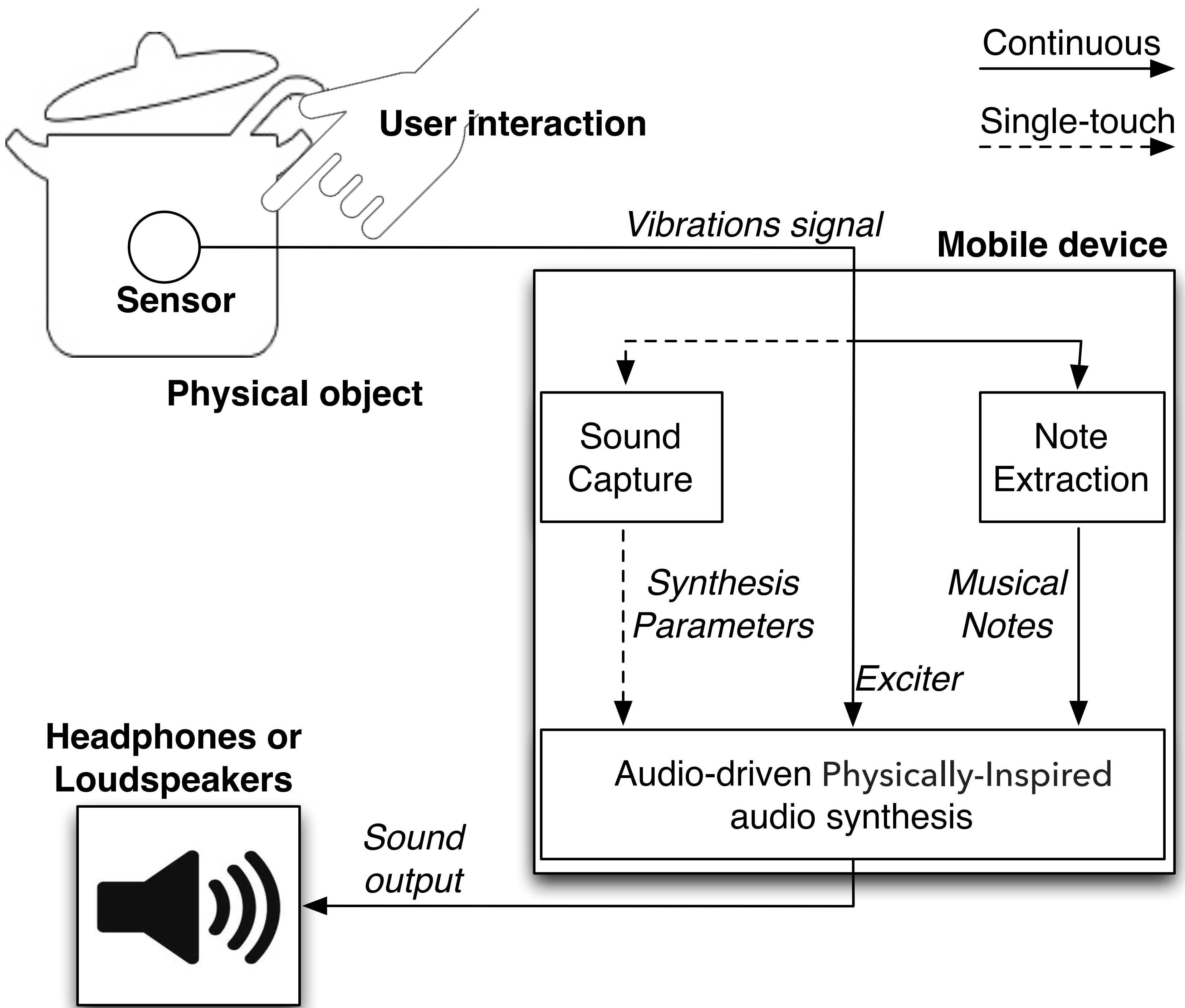
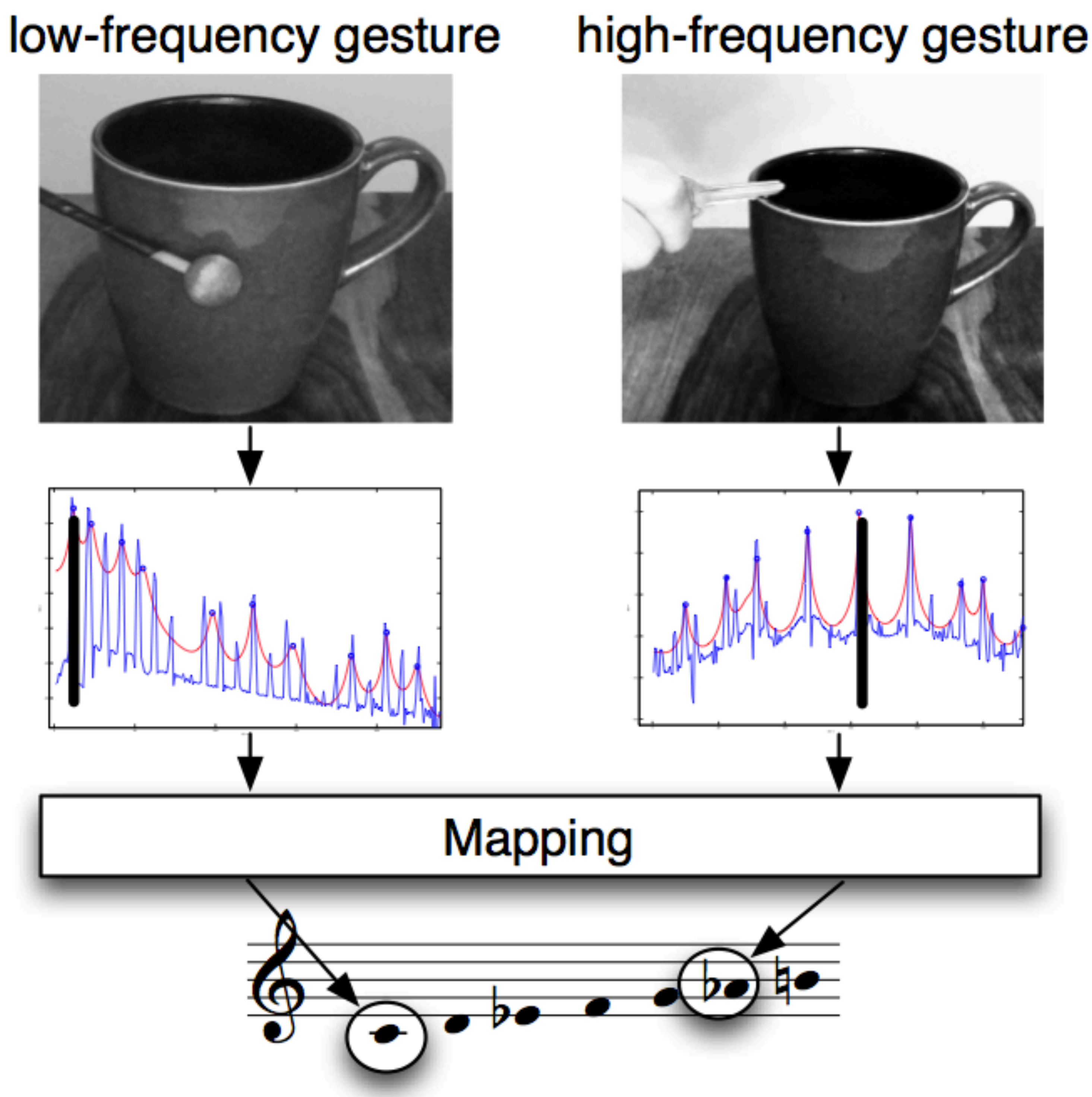
selector~ 2
scale 0. 0.02 100. 1000
s cof

CAN WE SONIFY THE WORLD?

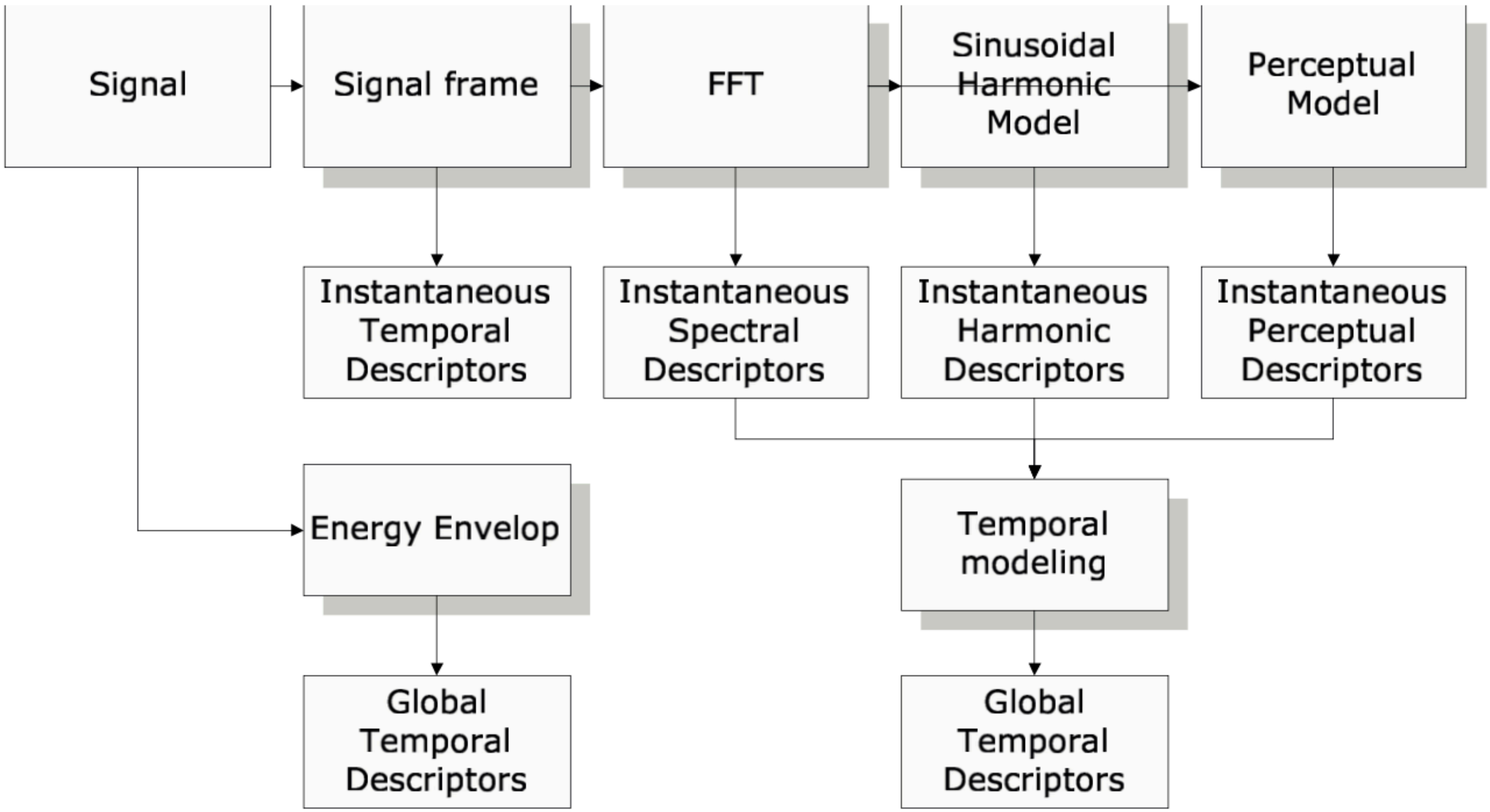


GESTURE MAPPING



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

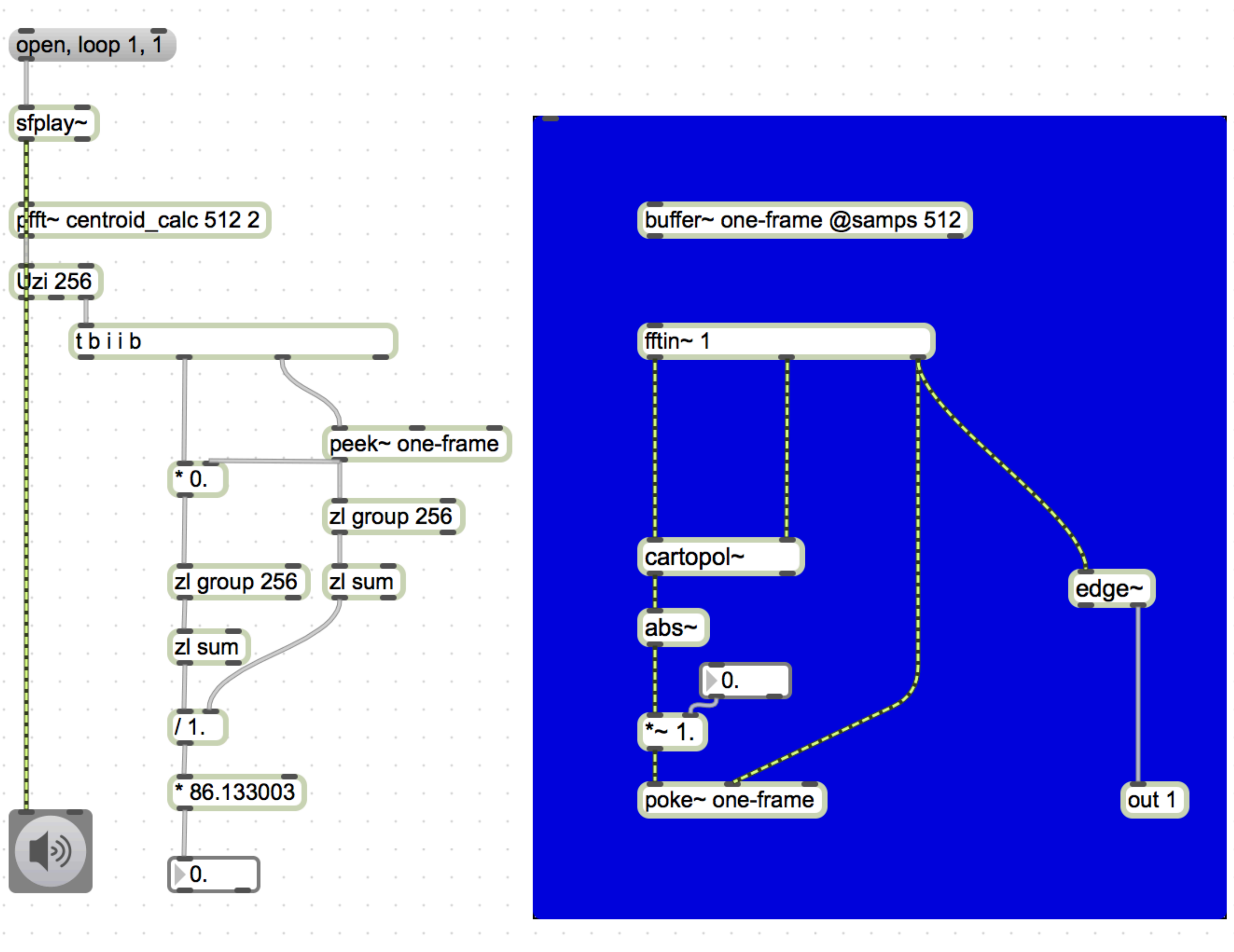
Spectral centroid (brightness) and spectral spread (bandwidth) are important features:

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

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

Where *x* are the frequencies of the spectrum and *p(x)* are the respective amplitudes; the spectral centroid is the *weighted average*

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

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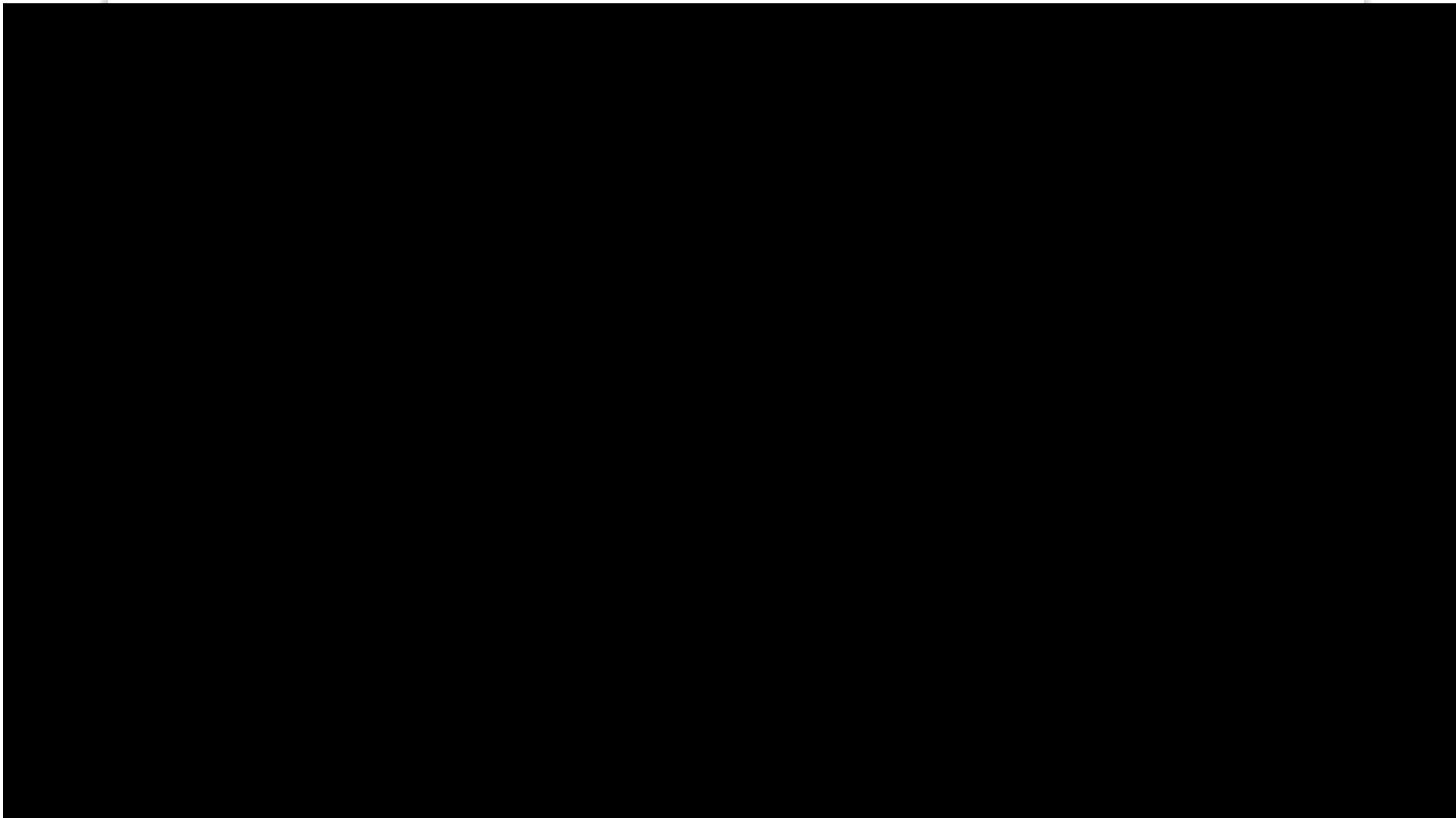
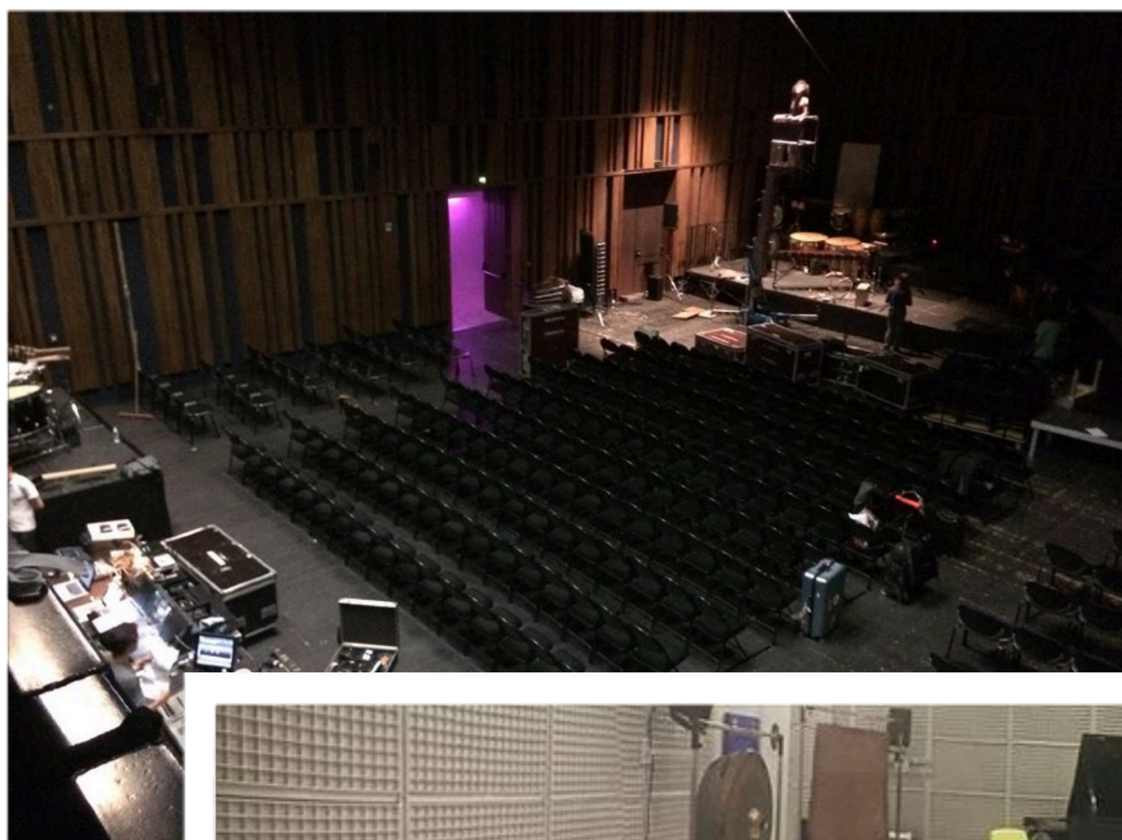


INSIDE-OUT

for smart percussions (2017)

commissioned by Ircam and Percussions de Strasbourg

first performance: june 2017, Paris



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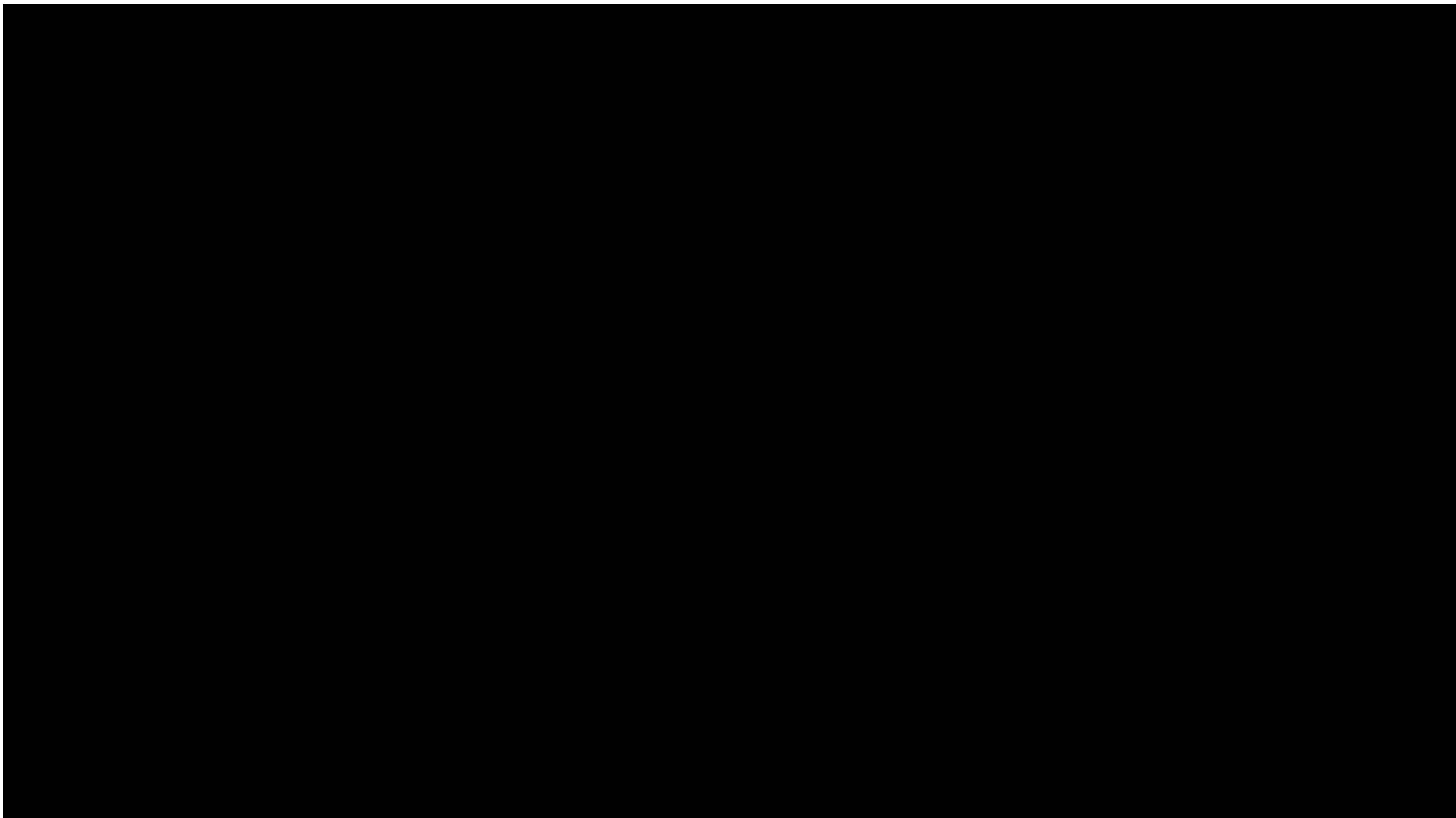

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- Physical modelling synthesis is a flexible framework to model the acoustic behaviours of physical objects

- 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
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- M. Puckette, The theory and techniques of electronic music, 2006

ANY QUESTIONS?

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