



HAL
open science

Impulse-Response and CAD-Model-Based Physical Modeling in FAUST

Pierre-Amaury Grumiaux, Romain Michon, Emilio Jesús Gallego Arias, Pierre Jouvelot

► **To cite this version:**

Pierre-Amaury Grumiaux, Romain Michon, Emilio Jesús Gallego Arias, Pierre Jouvelot. Impulse-Response and CAD-Model-Based Physical Modeling in FAUST. Linux Audio Conférence 2017, May 2017, Saint Etienne, France. 2017. hal-01526607v2

HAL Id: hal-01526607

<https://minesparis-psl.hal.science/hal-01526607v2>

Submitted on 7 Feb 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

IMPULSE-RESPONSE AND CAD-MODEL-BASED PHYSICAL MODELING IN FAUST

P.-A. GRUMIAUX, R. MICHON, E. GALLEGO ARIAS AND P. JOUVELOT

pierreamaury.grumiaux@gmail.com, rmichon@ccrma.stanford.edu,

{emilio.gallego_arias, pierre.jouvelot}@mines-paristech.fr (PSL Research University)

CONTEXT

The FAUST programming language [4] has proven to be well suited to implement physical models of music instruments using waveguides and model synthesis [1][2][3]. We developed two tools allowing to easily generate FAUST modal physical models:

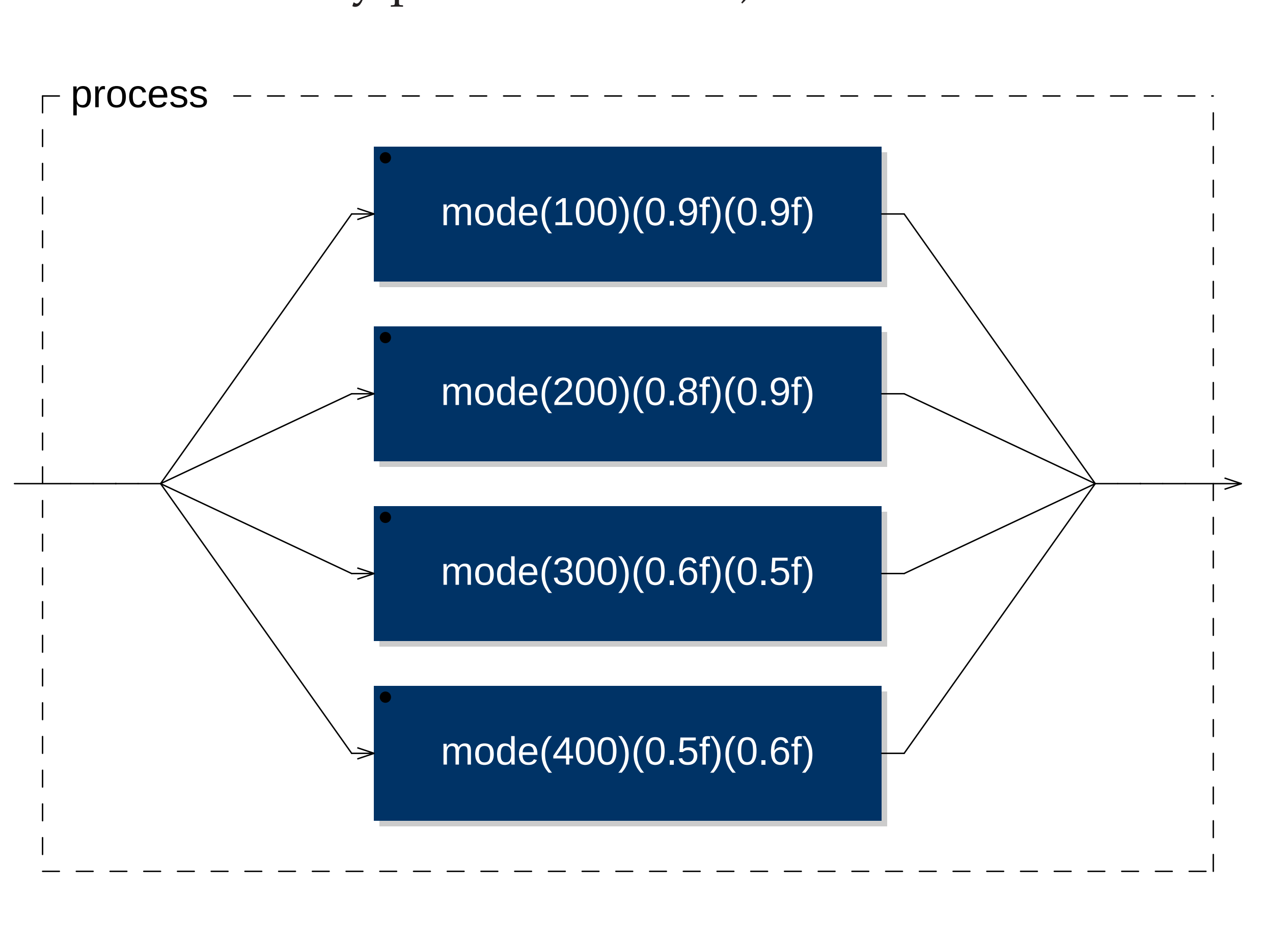
1. `ir2dsp.py` takes the audio file of an impulse response and converts it into a FAUST program implementing the corresponding modal physical model;
2. `mesh2dsp.py` outputs the same type of model from a `.stl` file specifying a 3D object.

FAUST MODAL PHYSICAL MODEL

Linear percussion instruments can be implemented using banks of resonant bandpass filters [2]. Each filter implements one mode of the system and is configured with 3 parameters : the frequency of the mode, its gain and its resonance duration (t_{60}). Its FAUST version, `modeFilter` below, uses a biquad filter (`tf2`) and computes its poles and zeroes for a given frequency and t_{60} .

```
modeFilter(f,t60) = tf2(b0,b1,b2,a1,a2)
with{
  b0 = 1;
  b1 = 0;
  b2 = -1;
  w = 2*PI*f/SR;
  r = pow(0.001,1/float(t60*SR));
  a1 = -2*r*cos(w);
  a2 = r^2;
};
mode(f,t60,gain) = modeFilter(f,t60)*gain;
```

Modal physical models are implemented using multiple parallel (`par` in FAUST) instances of `mode` calls. The FAUST-generated block diagram corresponding to such an implementation is presented below (we used arbitrary parameters here).



Such a model can be excited by a filtered noise impulse.



FUTURE DIRECTIONS

We plan to improve `ir2dsp.py` by using a better t_{60} measurement algorithm. For now, the calculation is done by measuring the bandwidth for each peak, while it would be a better approach to extract it from a time-frequency representation of the signal.

Regarding `mesh2dsp.py`, we would like to try other open-source packages than Elmer to carry out FEA.

IR2DSP.PY AND MESH2FAUST

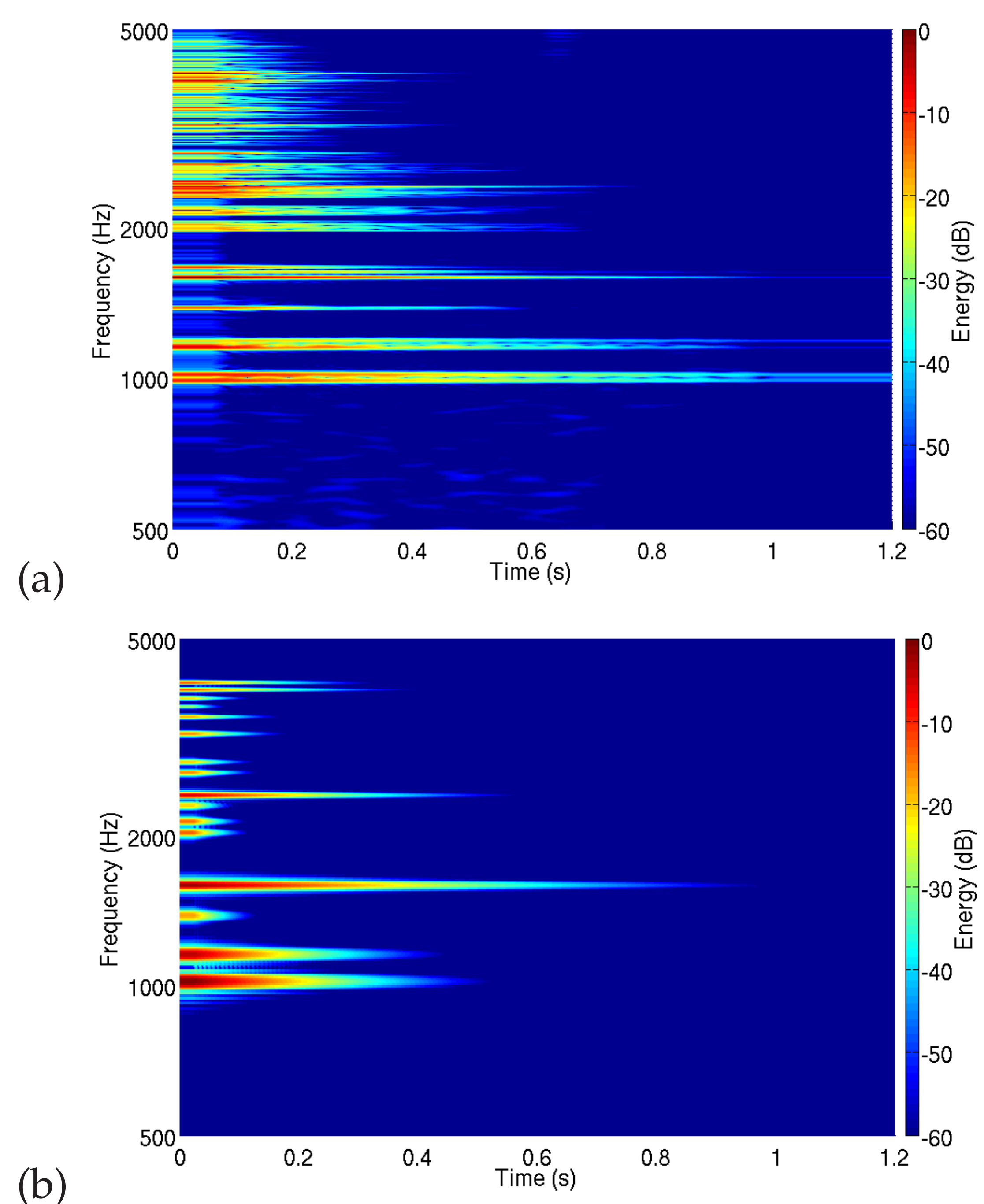
`ir2dsp.py` takes an audio file and extracts modal physical model-based information for each mode: frequency and gain, by carrying out peak detection; t_{60} , by measuring bandwidth at -3 dB. A FAUST file is then generated. With this tool, one can strike any object, record the resulting sound and turn it into a playable digital instrument.

`mesh2dsp.py` gives the same output, using a `.stl` file (describing a 3D object) as input, as follows:

- conversion of the input object to a mesh;
- Finite Element Analysis (FEA) using the Elmer package, with the Young modulus, Poisson coefficient and density of the material as parameters;
- frequency and gain computation from eigenvalues and mass participation for each mode;
- t_{60} values input (these values cannot be computed by this method unfortunately, so they are user-provided parameters).

EVALUATION

Spectrograms of (a) the recording of the IR of a can and (b) its `ir2dsp.py`-generated modal physical model:



The original and synthesized sound representations are relatively close (but see Future Directions).

ARTIFACTS

Source code available at: <https://github.com/rmichon/pmFaust/>

REFERENCES

- [1] R. Michon, J. O. Smith. *Faust-STK: a set of linear and nonlinear physical models for the Faust programming language*. In Proceedings of the DAFx-11 Conference, 2011
- [2] J. O. Smith. *Physical Audio Signal Processing for Virtual Musical Instruments and Digital Audio Effects*. W3K Publishing, 2010
- [3] J.-M. Adrien. *The Missing Link: Modal Synthesis*. In "Representations of Musical Signals", MIT Press, 1991
- [4] Y. Orlarey, D. Fober, S. Letz. *Syntactical and Semantical Aspects of Faust*. Soft Computing, 2004

Project funded by ANR FEEVER. Linux Audio Conf., St-Etienne, May 18-21, 2017.