Assessing the homogeneity of guitar tones

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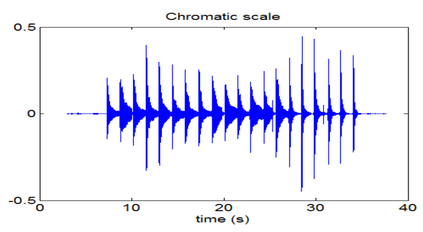
Outline

- Context of the PAFI project (Platform to aid in the manufacture of musical instruments)
- Aims at providing automated software tools to analyze measures
- Automatic segmentation, pitch and inharmonicity estimation
- Subspace Method and Enumeration for the spectral content of isolated tones
- Proposal to assess the decay of notes along the whole range by measuring the mobility

Overall system

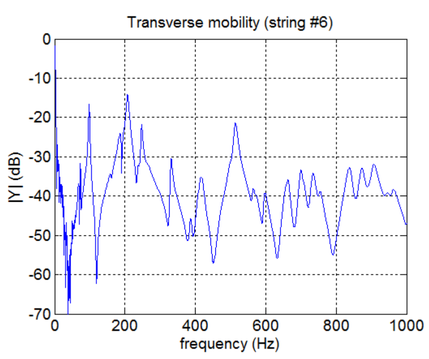


Automatic segmentation
Pitch and inharmonicity estimation

Subspace analysis of partials :
- Narrow band filtering
- ESPRIT method for estimation of modal damping and frequency
- ESTER method for enumeration of partial

Decay analysis with EDC
- Computing of the EDC curve
- Derivation of short time decay : EDC(200ms)

Synthesis (Woodhouse, AA 2004)
- Derive the response from the Y11 measurement
- Spectral domain synthesis, the response is derived by IFFT
- Uses a model for modal string damping taken from the quoted paper

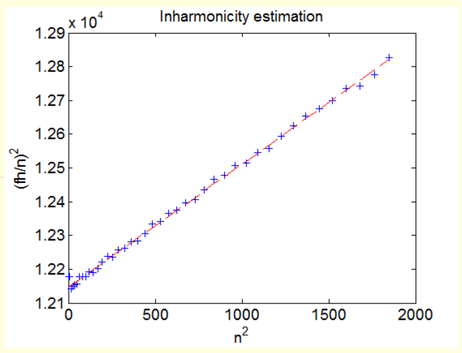


- Iterative detection of partials

$$f_{n+1}=2f_n-f_{n-1}$$

- Regression with

$$f_n=nf_0\sqrt{1+bn^2}$$



Subspace method (ESPRIT)
- Signal model :

$$x(t)=\sum_k b_k z_k^t+b(t)$$

- Noise and Signal subspace

$$S\perp N,\quad E_x=S\oplus N$$

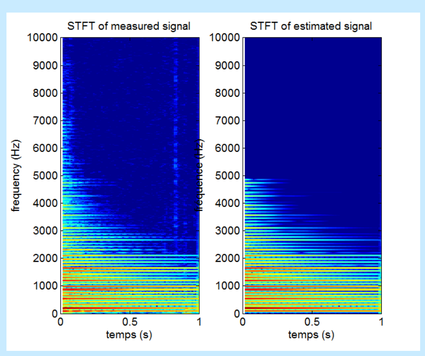
- Rotational Invariance

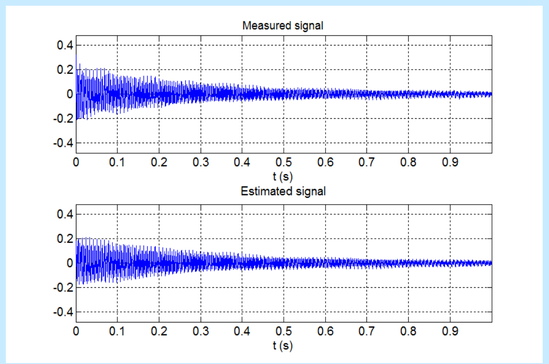
$$W_\uparrow=W_\downarrow R$$

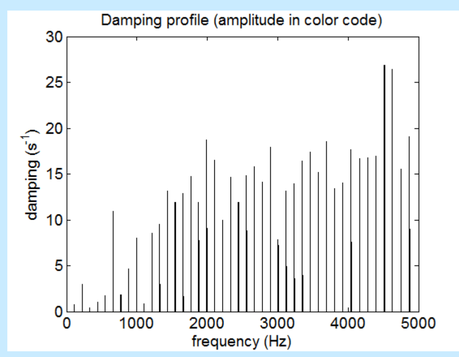
- Enumeration (ESTER)
  design a function J which is maximum when the rotational invariance is satisfied.

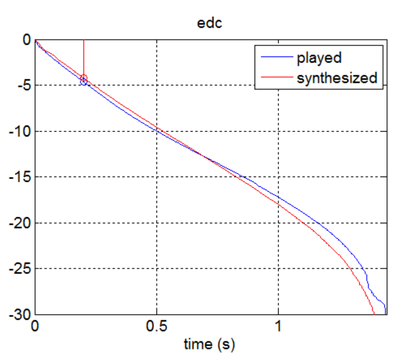
$$E(p)=W_\uparrow(p)-W_\downarrow(p)R(p)\quad J(p)=1/\|E(p)\|^2$$

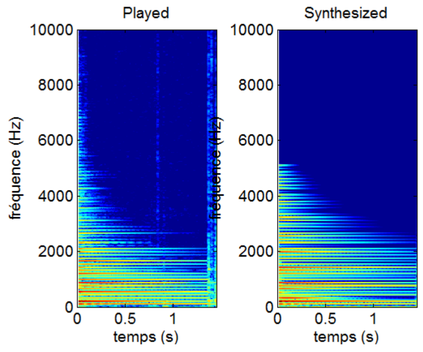
A2 example











EDC = Energy Decay Curve
- = energy remaining at t

$$E_{dc}=\int_t^\infty x^2(t)\,dt$$

- Since only transverse motion is considered : the faster decay is likely to be involved.

Spectral (hybrid) Synthesis
- Reciprocity principle

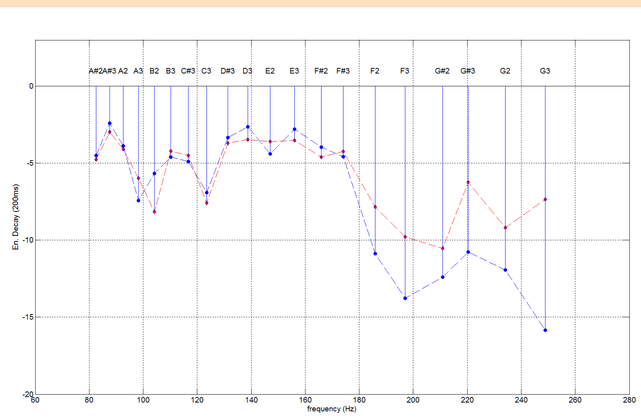
$$f(t,x_p)=f_0u(t)\rightarrow V_{br}=V_0\ \Leftrightarrow$$
$$f(t,x_{br})=f_0u(t)\rightarrow V(x_p)=V_0$$

- Derivation of the bridge coupled mobility

$$Yc^{-1}=(Y_{string}^{-1}+Y_{bridge}^{-1})^{-1}$$

- Transfer function H from the bridge to the plucking point (here we also take into account a plectrum width)

$$y(t)=TF^{-1}\{H(\omega)Y_c(\omega)\}$$



Conclusion
- A first step to describe the temporal decaying behavior of a guitar for all notes from mobility measurements
- Largely automated analysis
- Next steps : more tests for robustness, to take into account both polarizations, adjusting the string damping, non zero initial velocity.

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