6T1: Harmonic Model

Xavier Serra

Universitat Pompeu Fabra, Barcelona

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Harmonic model

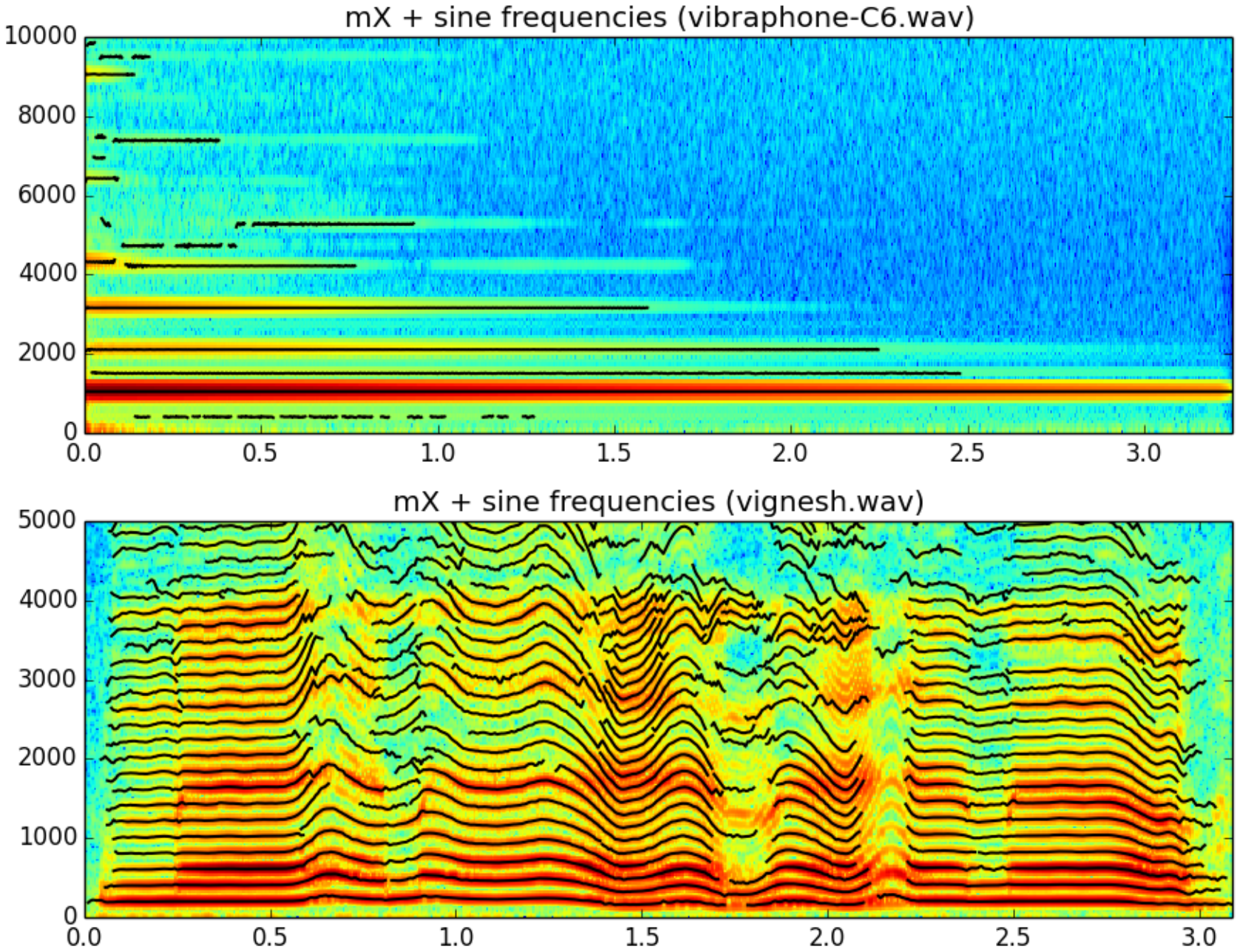
$$yh[n] = \sum_{r=1}^{R} A_r[n] \cos\left(2\pi r f_0[n] n\right)$$

R: number of harmonic components
$A_r[n]$: instantaneous amplitude
$f_0[n]$: fundamental frequency (Hz)

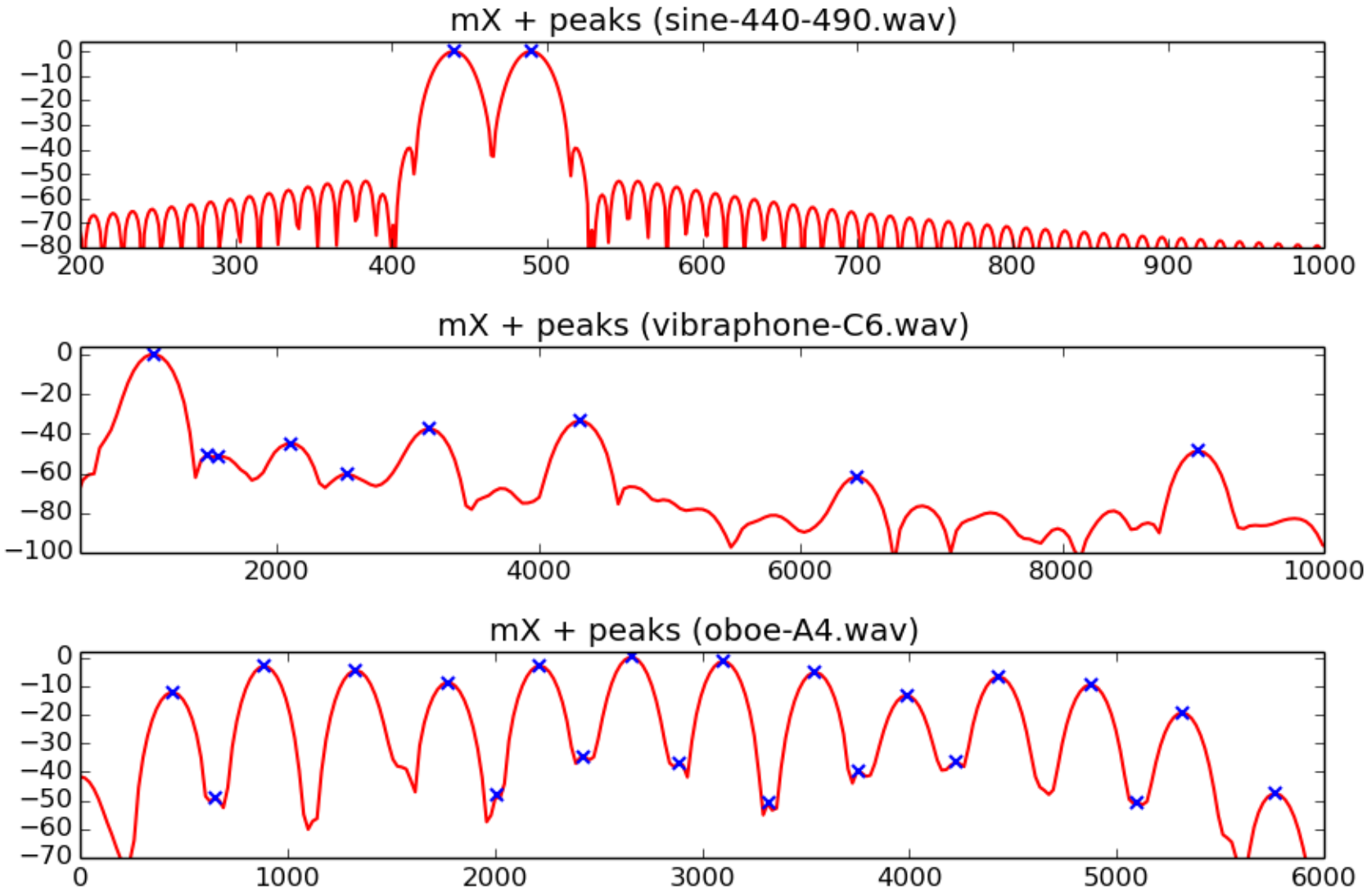
Spectral view

$$Yh_l[k] = \sum_{r=1}^{R_l} A_{(r,l)} W[k - r\ \hat{f}_{(0,l)}]$$

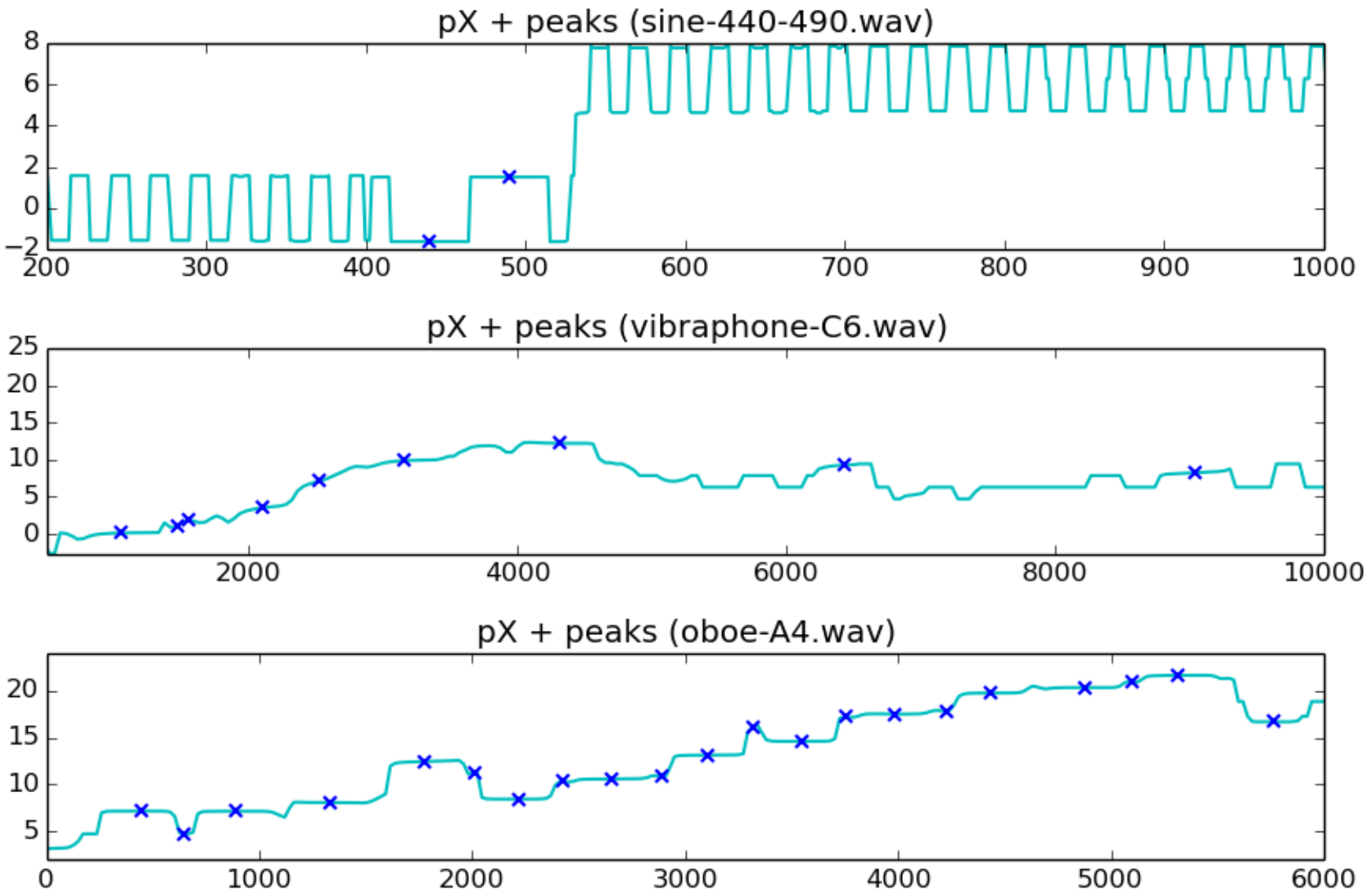
W : spectrum of analysis window
R : number of harmonics
A : amplitude of harmonic
$\hat{f}_0$: normalized fundamental frequency
l : frame number
r : harmonic number


mX + sine frequencies (vibraphone-C6.wav)
10000
8000
6000
4000
2000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
mX + sine frequencies (vignesh.wav)
5000
4000
3000
2000
1000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0

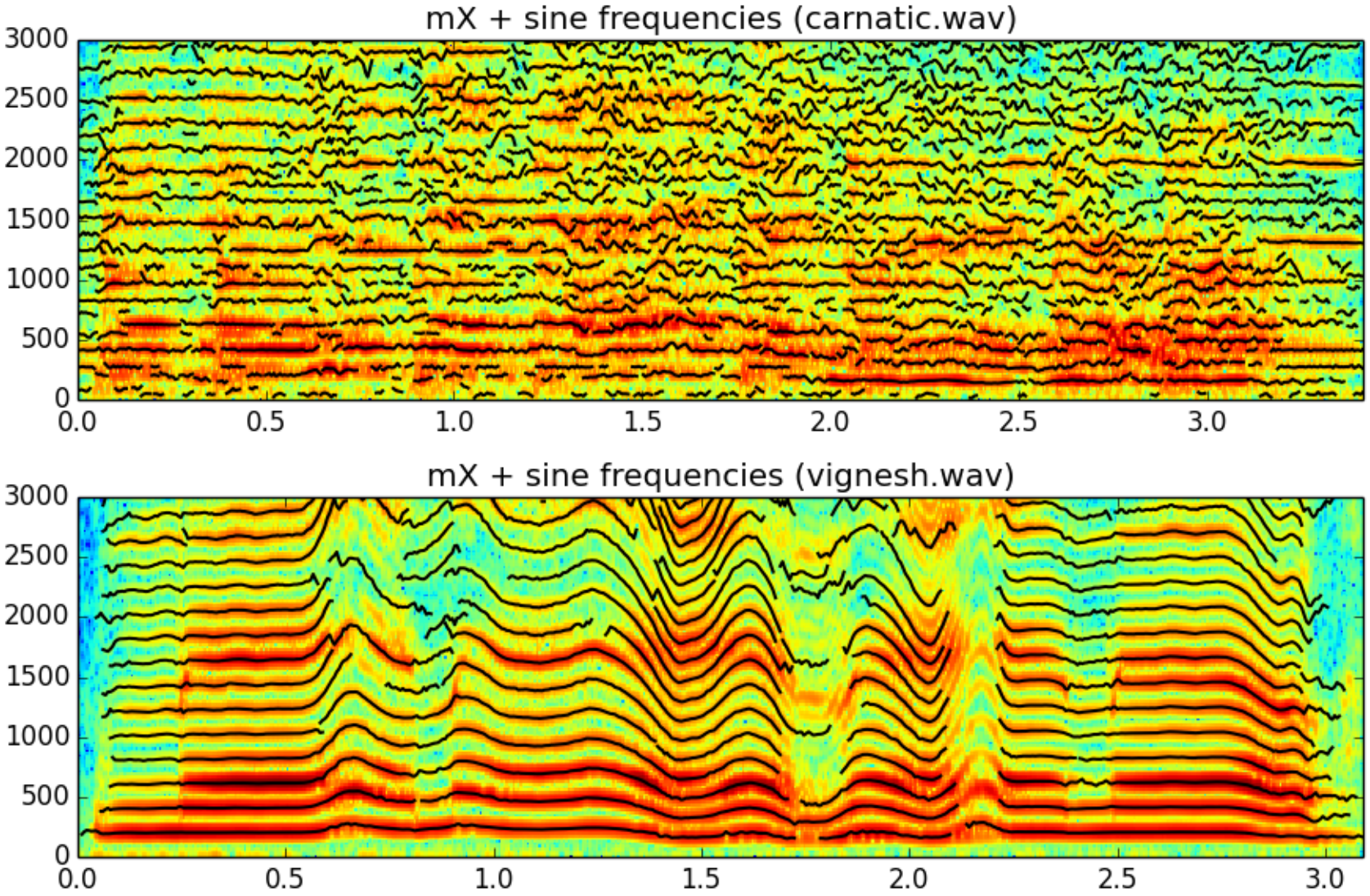
Sinusoids-partials-harmonics



Sinusoids-partials-harmonics



Polyphonic-monophonic signals



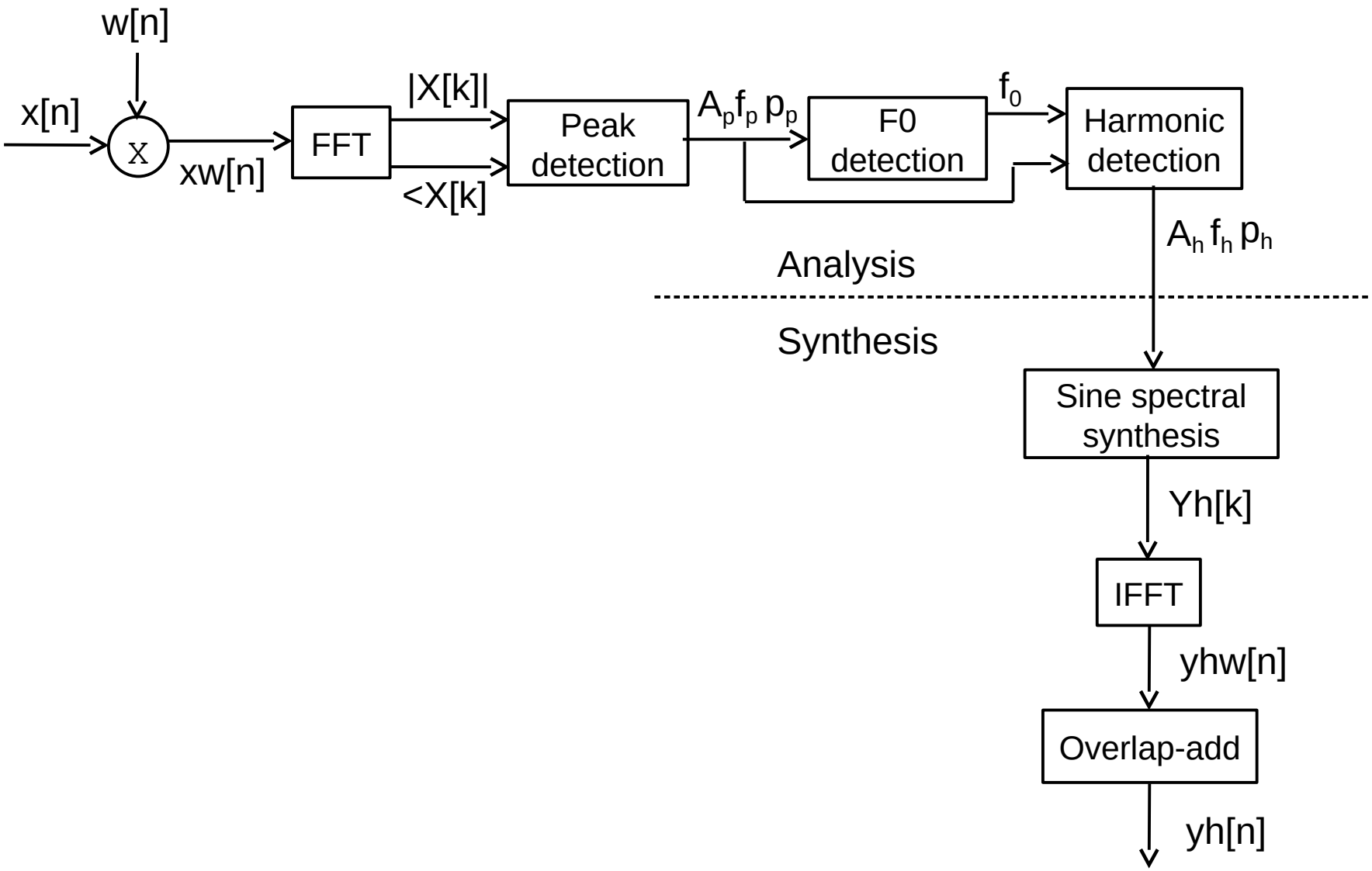
Harmonic detection

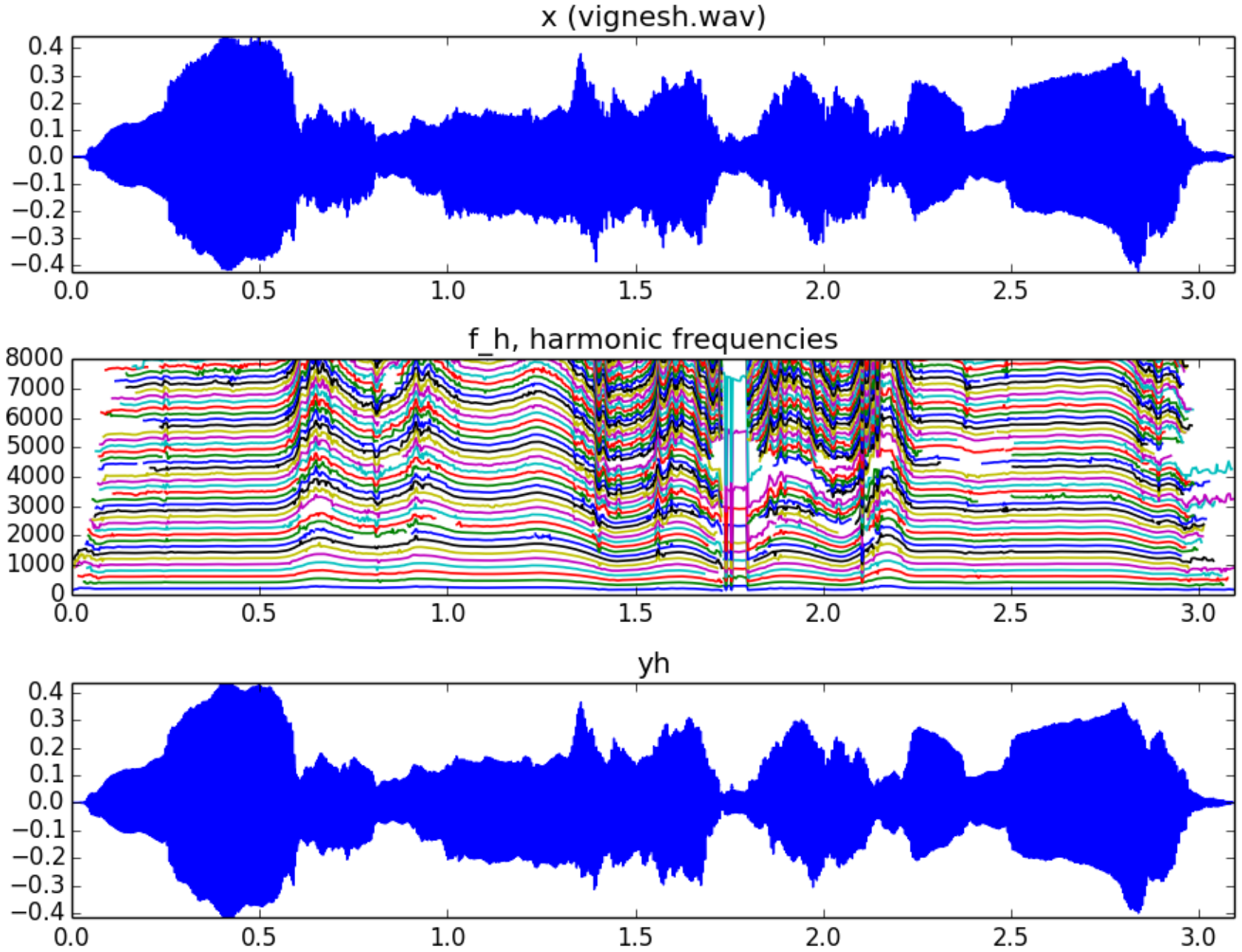
Harmonic ⟶ stable spectral peak whose frequency is close to a **multiple** of the fundamental frequency.

Condition for a peak f_p to be a harmonic f_h:

$$f_p[l] = f_h[l] \text{ if } \left(\left|f_p[l] - \left(h * f_0[l]\right)\right| < threshold\right)$$
$$\text{and exists } f_h[l-2], f_h[l-3], \ldots, f_h[l-L]$$

Harmonic model system




x (vignesh.wav)
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.4
0.0
0.5
1.0
1.5
2.0
2.5
3.0
f_h, harmonic frequencies
8000
7000
6000
5000
4000
3000
2000
1000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
yh
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.4
0.0
0.5
1.0
1.5
2.0
2.5
3.0

References and credits

- More information in:https://en.wikipedia.org/wiki/Harmonic_series_(music)

  https://en.wikipedia.org/wiki/Harmonic
- Sounds from: http://www.freesound.org/people/xserra/packs/13038/
- Slides released under CC Attribution-Noncommercial-Share Alike license and code under Affero GPL license; available from https://github.com/MTG/sms-tools

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