New multi-carrier demodulation method applied to gearbox vibration analysis

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Context

- Health monitoring for aeronautic power transmission systems
- Incipient fault detection and localization in complex mechanical devices

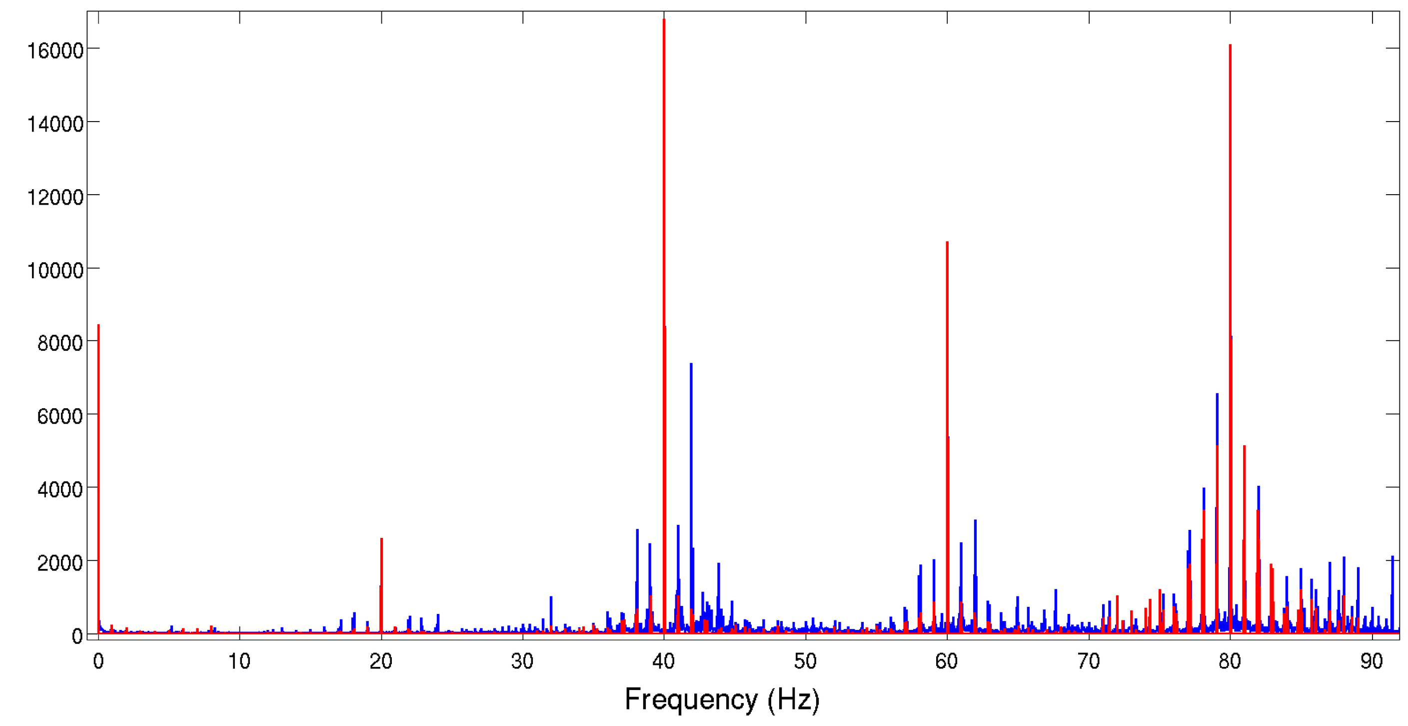
Main results

- Gearbox signal : presence of modulations around several carriers
- L2 optimal demodulation ⇔ low rank approximation

Gearbox vibration signal model

$$s(t) = s_{eng}(t) \times (1 + s_1(t) + s_2(t))$$

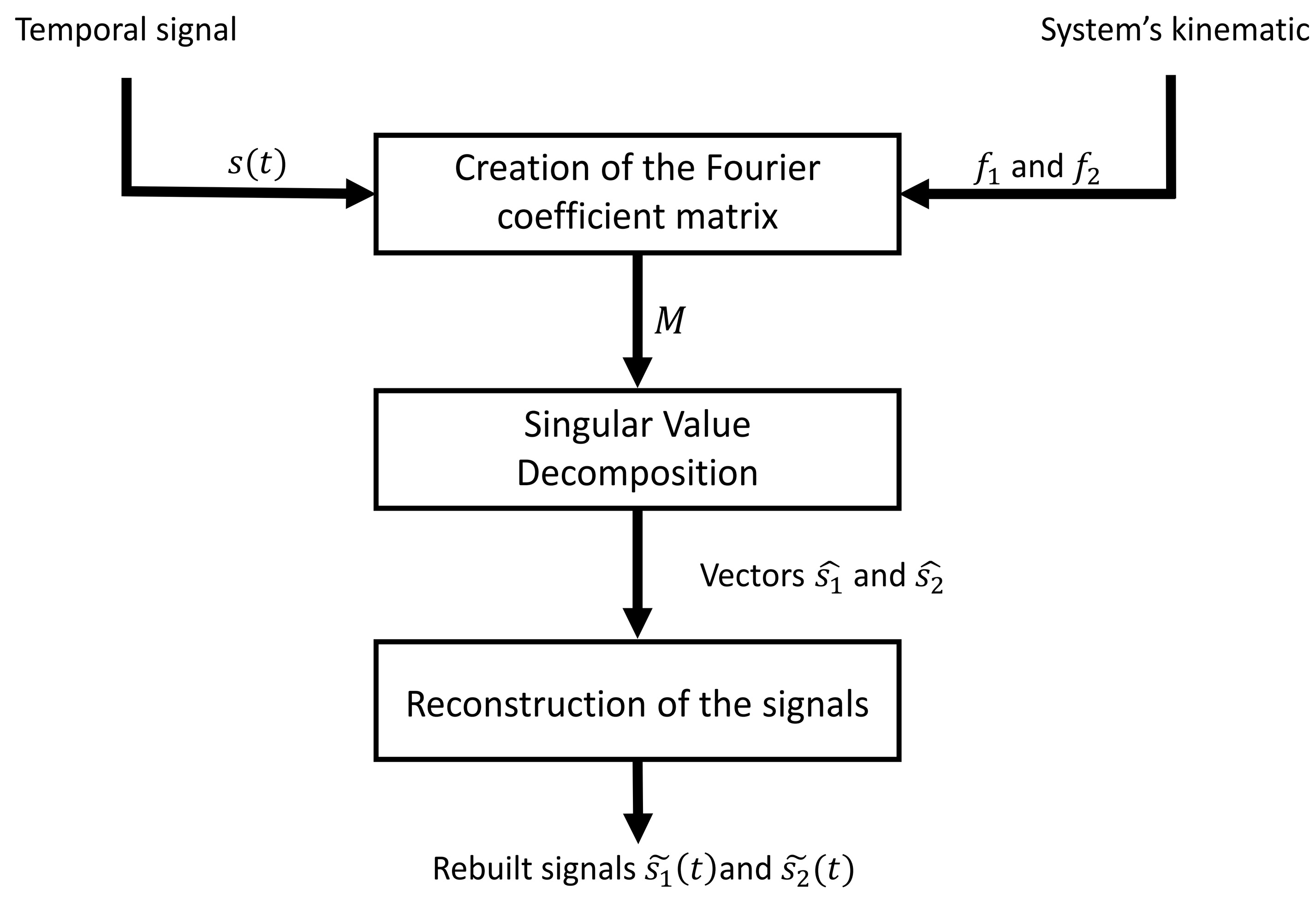
- $s(t)$ vibration signal
- $s_{eng}(t)$ meshing signal
- $s_1(t)$ gear 1 vibration signal
- $s_2(t)$ gear 2 vibration signal



Multi-carrier demodulation method

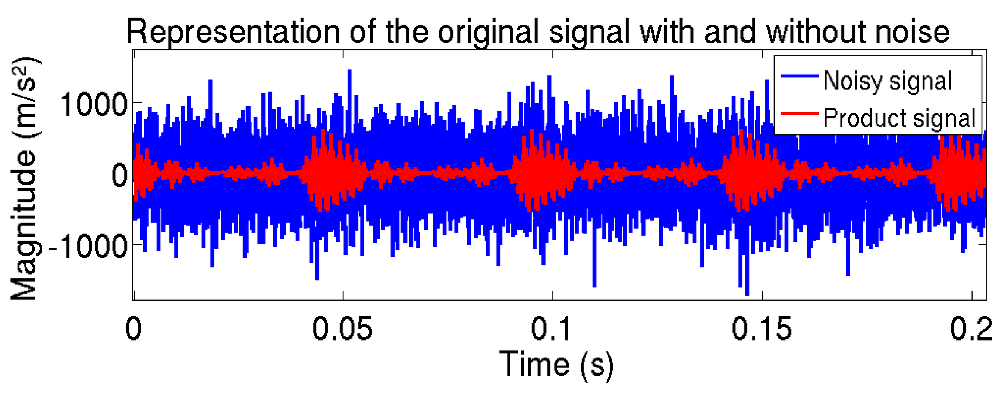
$$s(t) = s_n(t) \times s_p(t)$$

$$C_1(\hat{S}_n, \hat{S}_p) = \left\| M_S - S_n S_p^T \right\|_{Fro}^2$$



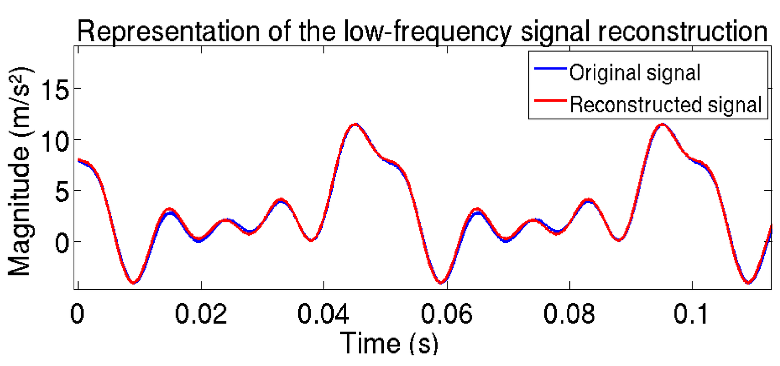
Numerical simulations

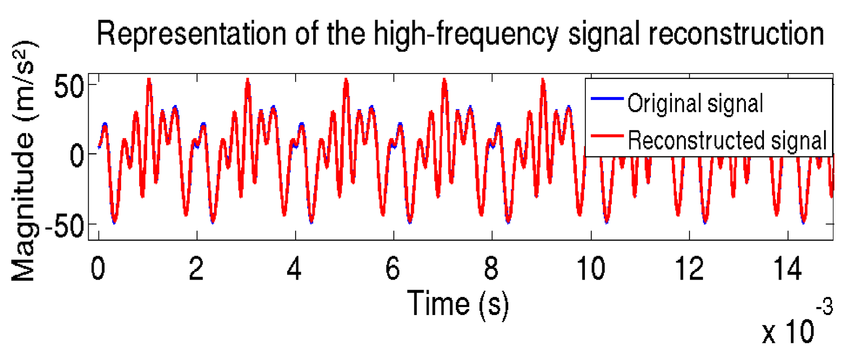
- Generation of a product with two signals with noise



$$f_1 = 500Hz$$
$$f_2 = 20Hz$$
$$SNR = -10dB$$

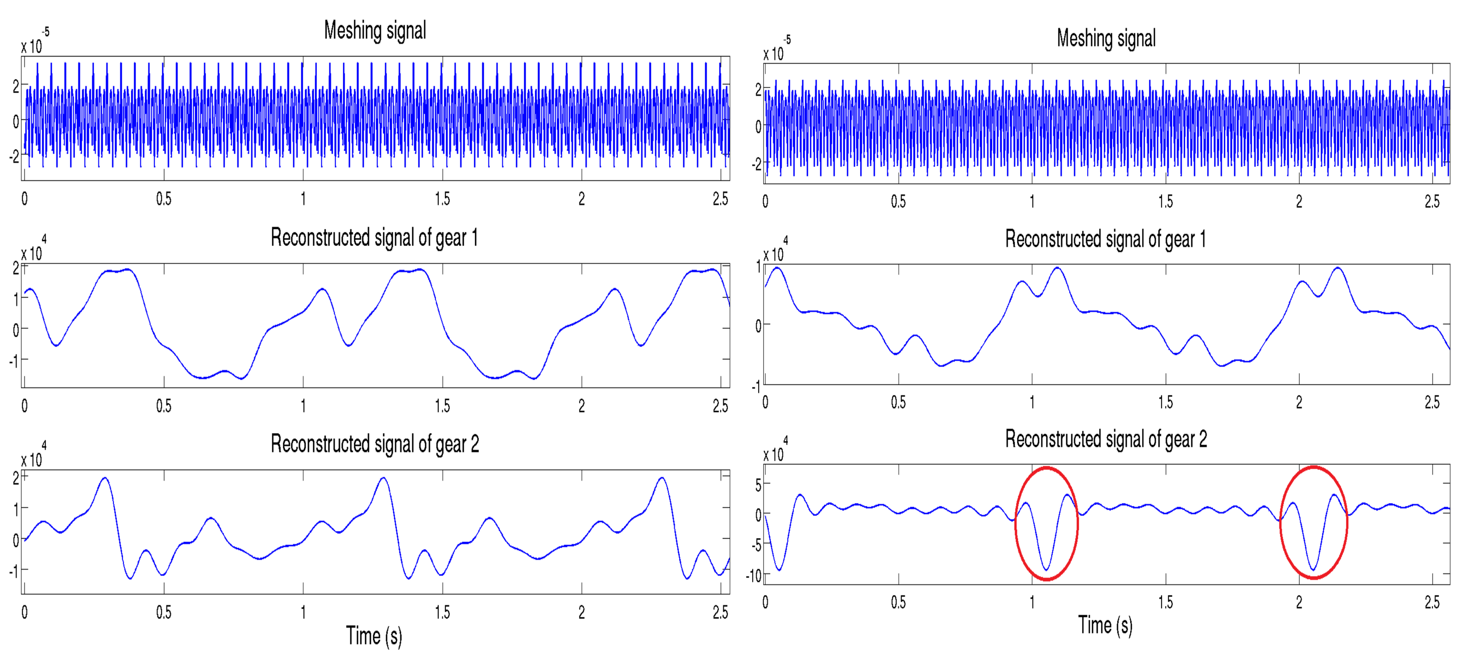
- Separation of the product into its two components





Experimental validation

- Vibration measurements on a gearbox test bench
  - ✓ Rotation frequencies : $f_1 = 16{,}75Hz$, $f_2 = 17Hz$
  - ✓ Meshing frequency : $f_e = 338Hz$
- Sound and faulty conditions of the gears



Conclusion and Perspectives :

- Method enabling the separation of a product signal into its components with a single
- The recovered signals are representative of the mechanical system vibration
- Efficient signal denoising enabling the use of simple fault indicators
- Extension of the method to phase-amplitude demodulation problems
- Study on more complex signals coming from more elaborate systems

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