Processing heartrate by wavelet method for emergency doctors

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Introduction and preliminaries

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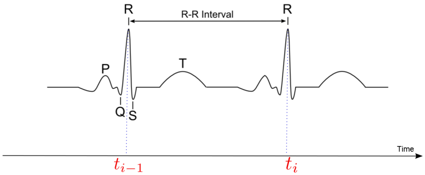
- **How to?** Extract and analyze the frequency components that modulate the behavior of the heartbeat
- **Go further?** Ensure that the analysis is more faster. Or even better make a quasi real-time solutions

Notation and models

Let us denote $(t_i)_{i=1,\ldots,N}$, instants corresponding to R pics. We consider the RR-time series: $X(t_i) = (t_i - t_{i-1})$.



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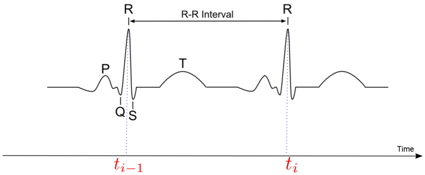

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- The low Frequency (LF) band $[\omega_1, \omega_2] = [0.04\ Hz,\ 0.15 Hz]$ associated with orthosympathic system (accelerator)

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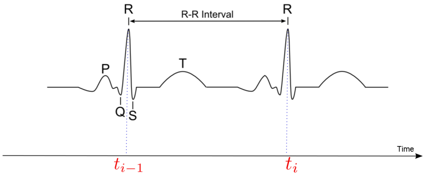

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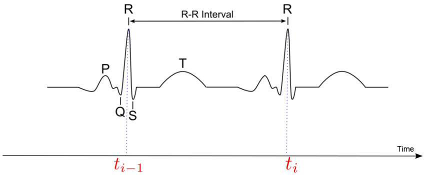

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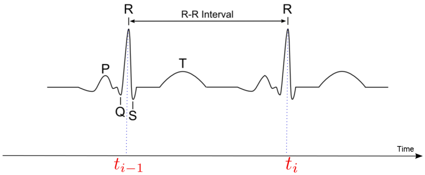

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Hence the importance of extracting HF and LF energies.

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The random nature of the tasks performed by emergency doctors, suggest that $X(t)$ may be modeled by a local stationary process:

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To extract the LF energy (on $[\omega_1, \omega_2]$) and the HF energy (on $[\omega_2, \omega_3]$)

The wavelet method is the most suitable

Extracting HF and LF energies

The idea is to find two wavelets ψ_1 and ψ_2 such that :

- $W_1(b) = \int_{\mathbb{R}} \psi_1(t-b)\, X(t)\, dt$ one can calculate $|W_1(b)|^2$, the energy associated with the LF band $[\omega_1, \omega_2]$ and localized around the instant b

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The alternative is to introduce the concept of pseudo compact support....

The concept of the ρ-pseudo compact support

Let $0 < \rho < 1$ and $g \in L^2(R)$, we will say that g have a ρ-pseudo support I if

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$\psi_1(t) = e^{i\eta t}\psi(\lambda t)$ where:

$$\lambda = \frac{\omega_2 - \omega_1}{\Lambda_2 - \Lambda_1} \text{ et } \eta = \frac{\omega_1 + \omega_2}{2} - (\omega_2 - \omega_1)\frac{\Lambda_2 + \Lambda_1}{\Lambda_2 - \Lambda_1}$$

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Its temporal support is then given by:

$$[\frac{\Lambda_2 - \Lambda_1}{\omega_2 - \omega_1}L_1, \frac{\Lambda_2 - \Lambda_1}{\omega_2 - \omega_1}L_2]$$

Application to the Gabor wavelets

The Gabor wavelet ψ is defined by:

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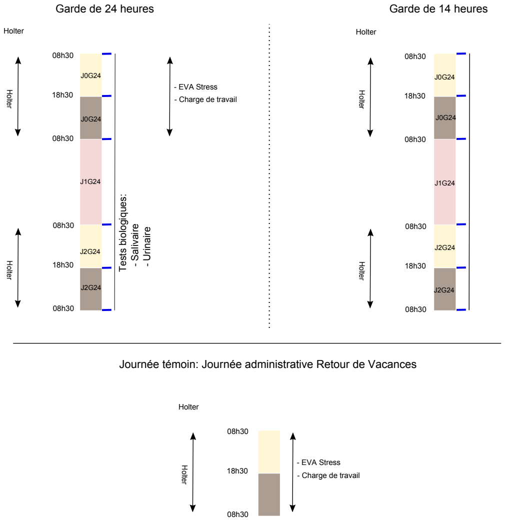
$$\eta_1 = \frac{\omega_1 + \omega_2}{2} \text{ and } \sigma_1 = \frac{2L}{\omega_2 - \omega_1}$$
$$\eta_2 = \frac{\omega_2 + \omega_3}{2} \text{ and } \sigma_2 = \frac{2L}{\omega_3 - \omega_2}$$

In addition $|\rho\ pseudo\ Supp\ \psi_1| = \dfrac{4L^2}{\omega_2 - \omega_1}$ et $|\rho\ pseudo\ Supp\ \psi_2| = \dfrac{4L^2}{\omega_3 - \omega_2}$ for $\rho = 0.9995$

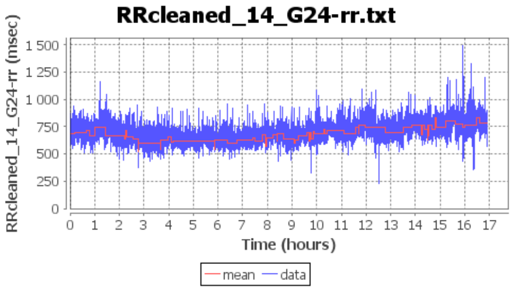
Le protocole des mesures

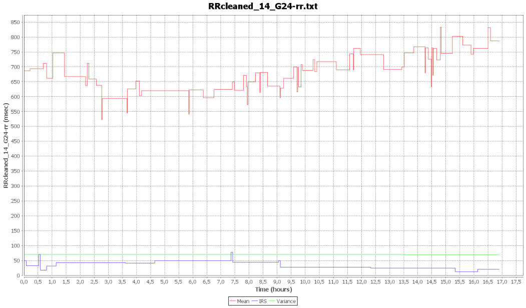


- 19 médecins urgentistes: population facile à suivre, susceptible d'être exposée au stress
- suivi sur 7 jours, avec prélèvement:
  - Urinaire : Cortisol, catécholamines, IL8
  - Salivaire : cortisol, DHEA-S, leptine, IgAs, lysozyme
- En fin de garde: une évaluation du stress, fatigue, la charge de travail, psychologique

$\Longrightarrow$ On s'interesse à l'activité cardiaque mesurée par Holter

Quelques graphiques





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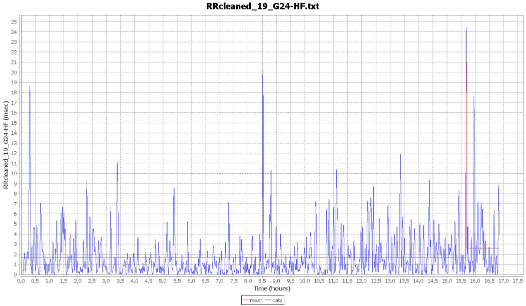

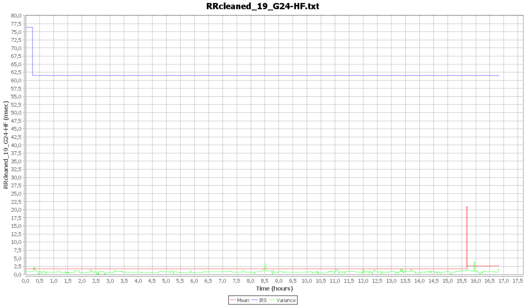

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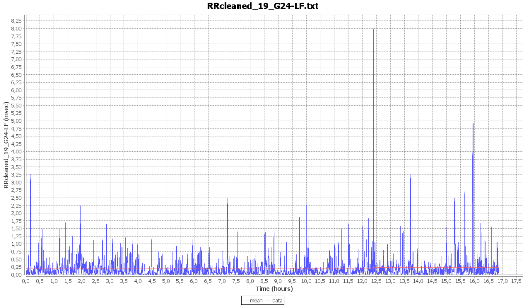

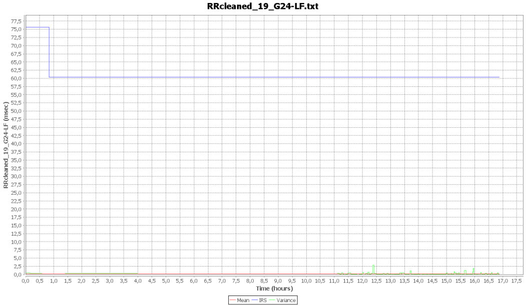

Le soft java en action