Heart Rate Variability

PPG & BCG

2022-04-01

HRV — PPG

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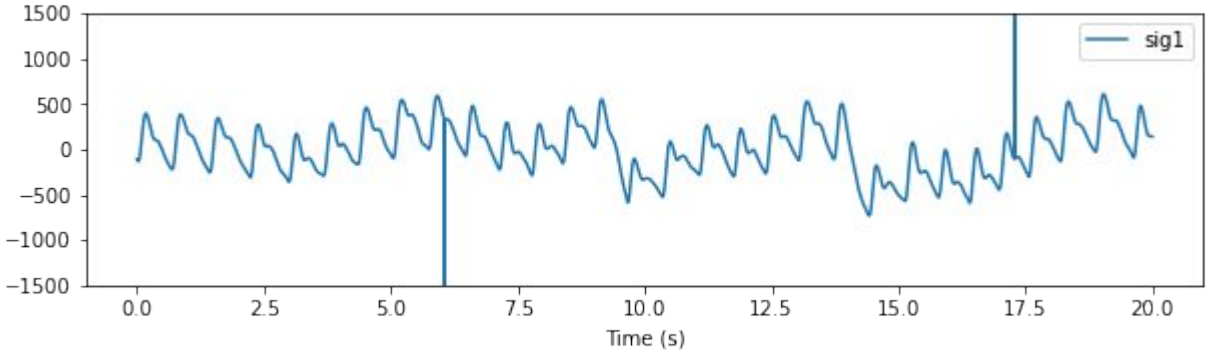
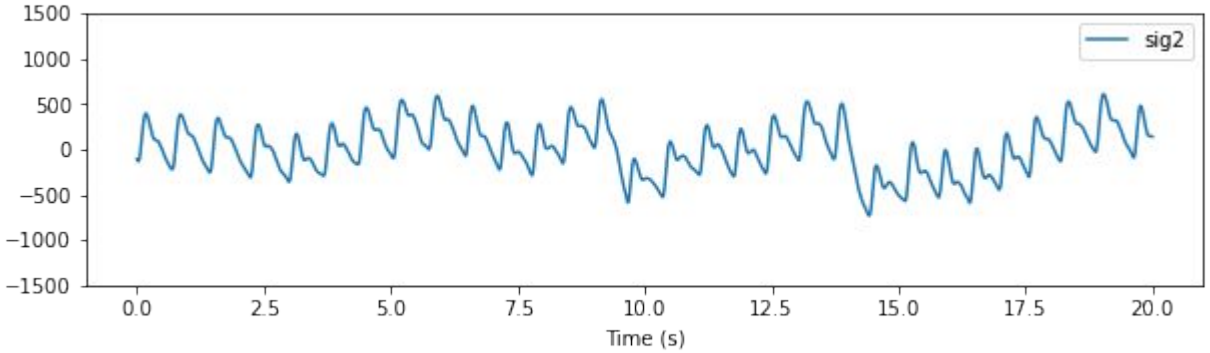
- Median Filter
- Band Pass Filter (FIR)
- Normalization
- Find Peaks
- Intervals
- Interpolation
- HRV

```
sig2 = signal.medfilt(sig1, kernel_size=3)
```





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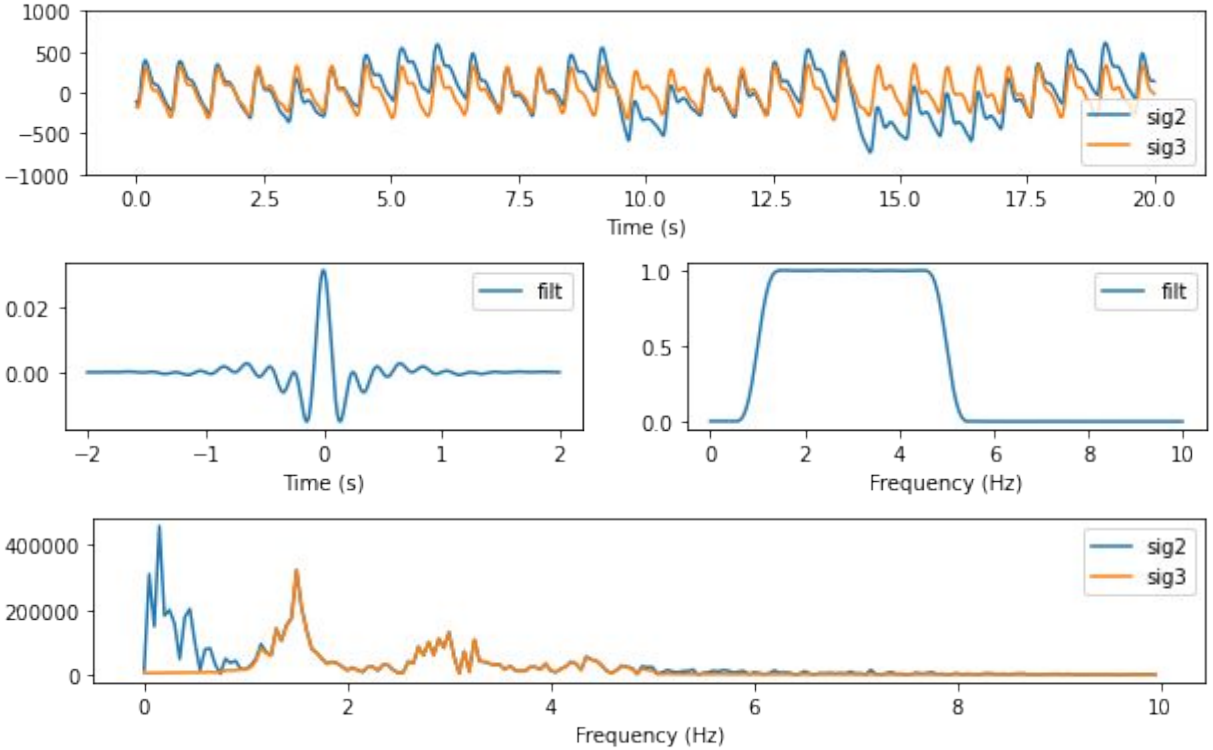
```
filt = signal.firwin(numtaps=1024, cutoff=[1, 5], pass_zero='bandpass', fs=256)
sig3 = signal.convolve(sig2, filt, mode='same')
```



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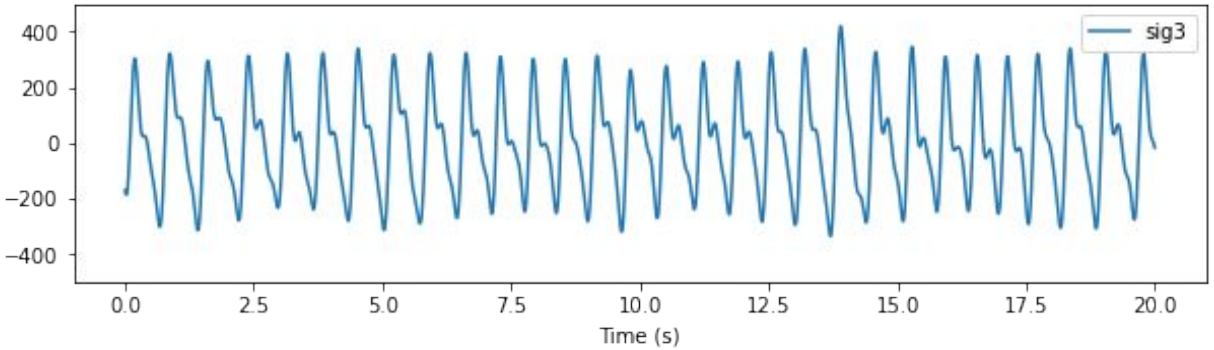
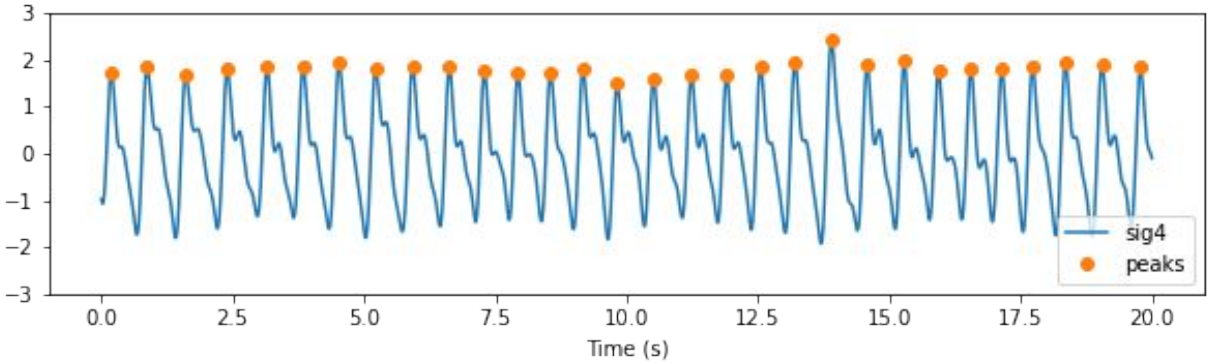
```
sig4 = (sig3 - sig3.mean()) / sig3.std()
peaks, _ = signal.find_peaks(sig4, prominence=1)
```





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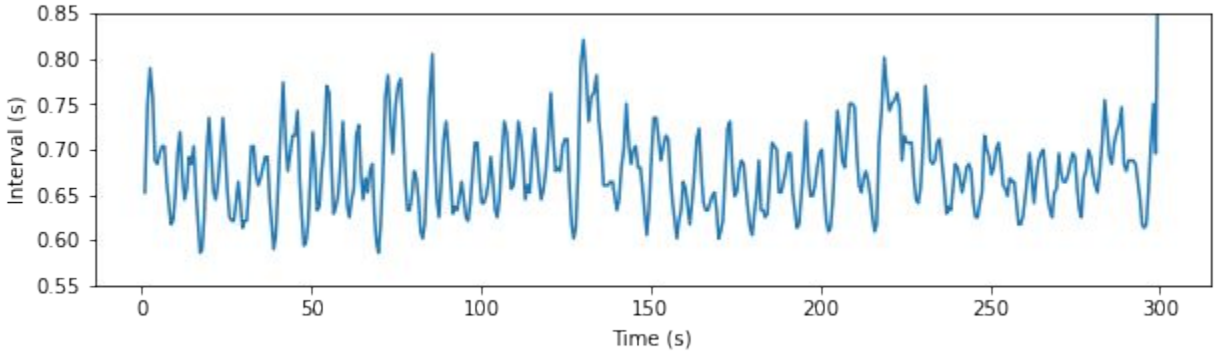
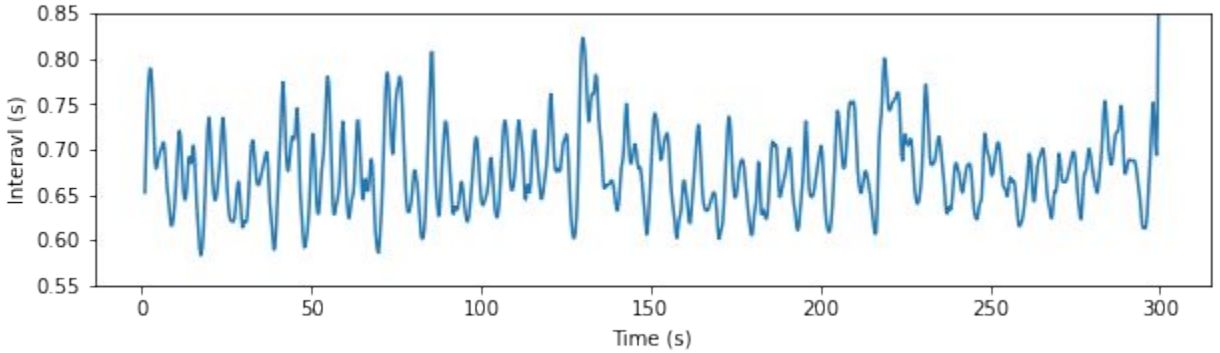
```
peak_time = peaks / 256
t = peak_time[1:]
d = peak_time[1:] - peak_time[:-1]
t_interp = np.linspace(t.min(), t.max(), 1000)
s_interp = interpolate.interp1d(t, d, kind='cubic')(t_interp)
```





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s_fft = np.fft.fft(s_interp - s_interp.mean())
s_freq = np.fft.fftfreq(len(s_interp), d=t_interp[1] - t_interp[0])
f_sample = 1 / (t_interp[1] - t_interp[0])
s_psd = (1/(f_sample*len(s_interp))) * abs(s_fft) ** 2

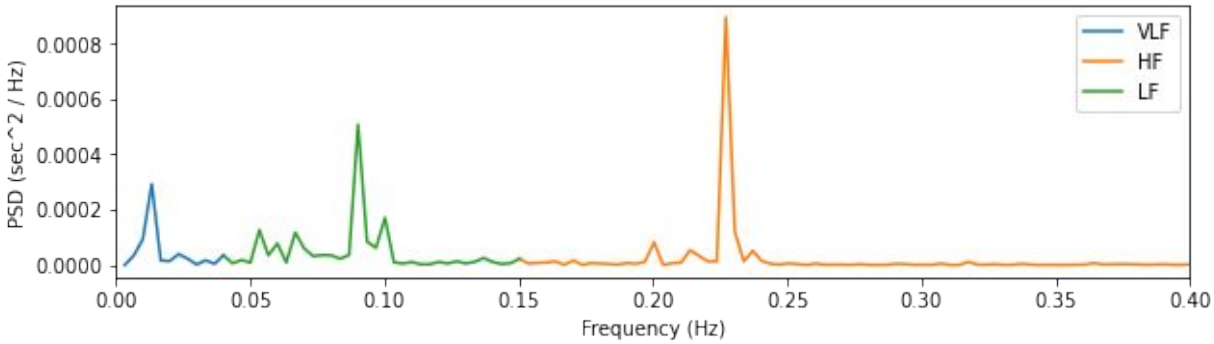
f_step = s_freq[1]
r_vlf = (np.array([0.0033, 0.04]) / f_step + 0.5).astype(int)
r_hf = (np.array([0.15, 0.4]) / f_step + 0.5).astype(int)
r_lf = (np.array([0.04, 0.15]) / f_step + 0.5).astype(int)

range_vlf = range(r_vlf[0], r_vlf[1]+1)
range_hf = range(r_hf[0], r_hf[1]+1)
range_lf = range(r_lf[0], r_lf[1]+1)

VLF_power = s_psd[range_vlf].sum() * f_step * 1000000
LF_power = s_psd[range_lf].sum() * f_step * 1000000
HF_power = s_psd[range_hf].sum() * f_step * 1000000
LF_HF = LF_power / HF_power

LF_peak = s_freq[range_lf][np.argmax(s_psd[range_lf])]
HF_peak = s_freq[range_hf][np.argmax(s_psd[range_hf])]
```

```
VLF power :  146.118 ms^2
LF power  :  415.294 ms^2
HF power  :  388.493 ms^2
LF peak   :    0.090 Hz
HF peak   :    0.227 Hz
LF/HF     :    1.069
```



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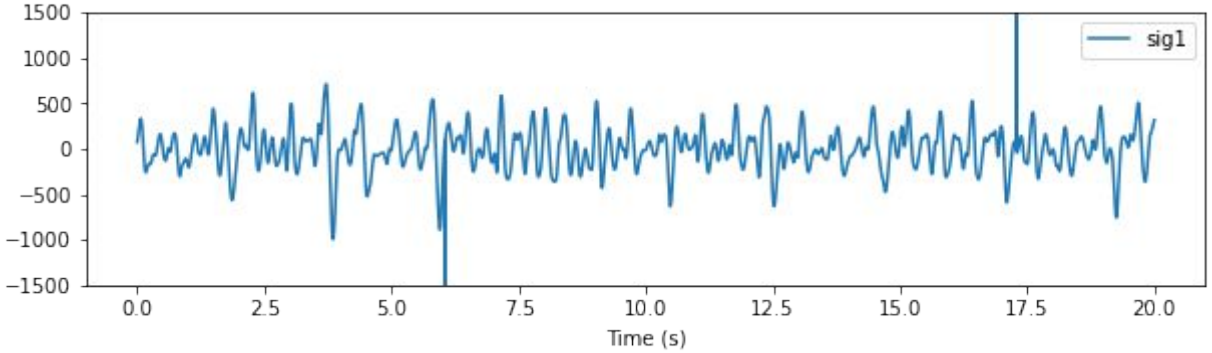

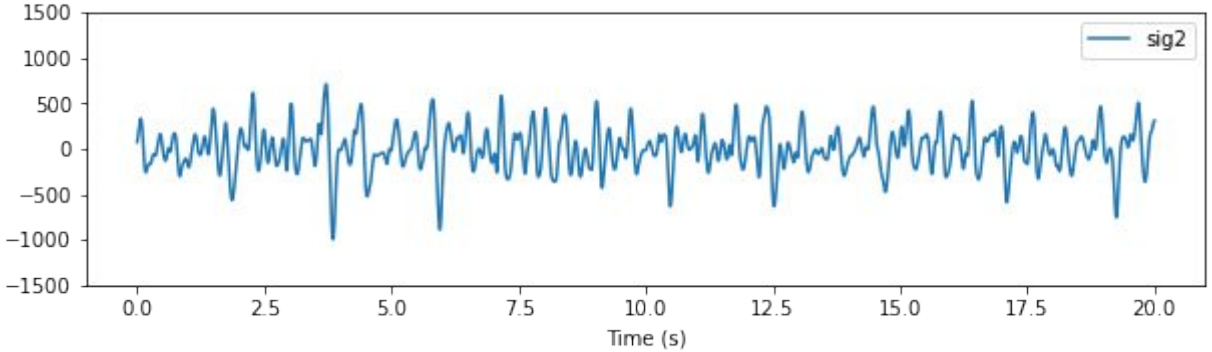

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filt = signal.firwin(numtaps=1024, cutoff=[0.5, 2.5], pass_zero='bandpass', fs=256)
sig3 = signal.convolve(sig2, filt, mode='same')
```

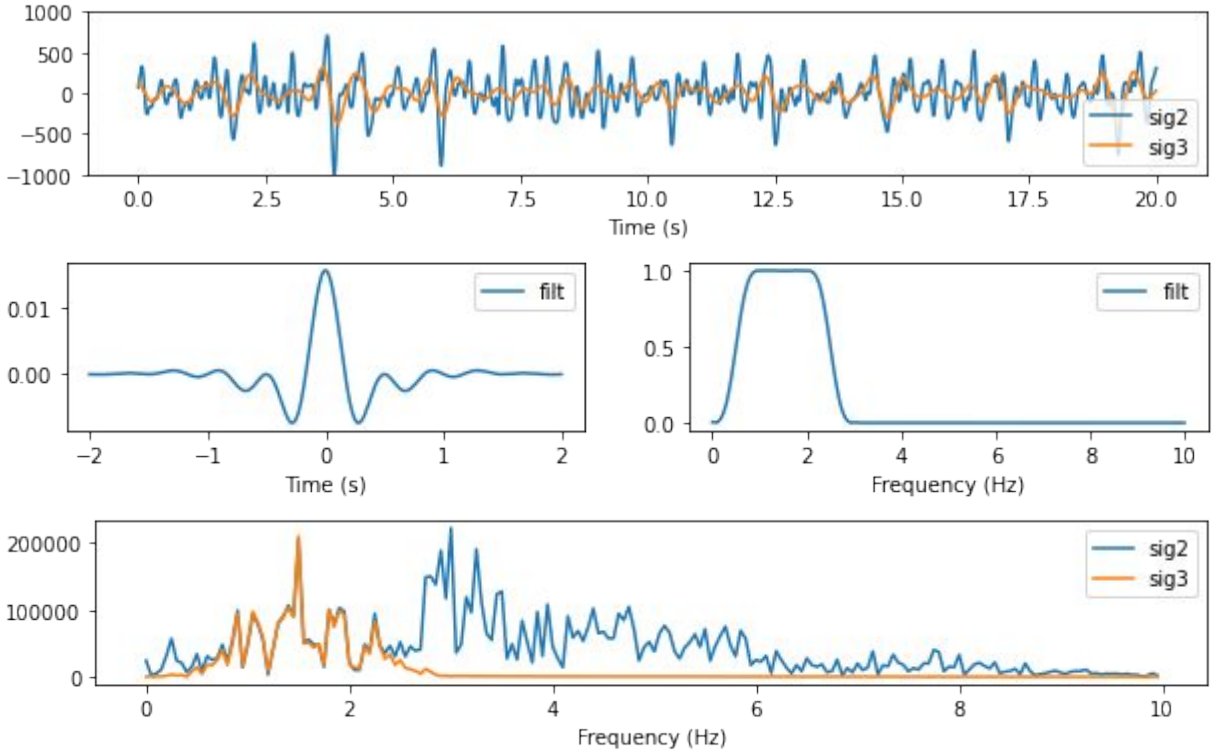

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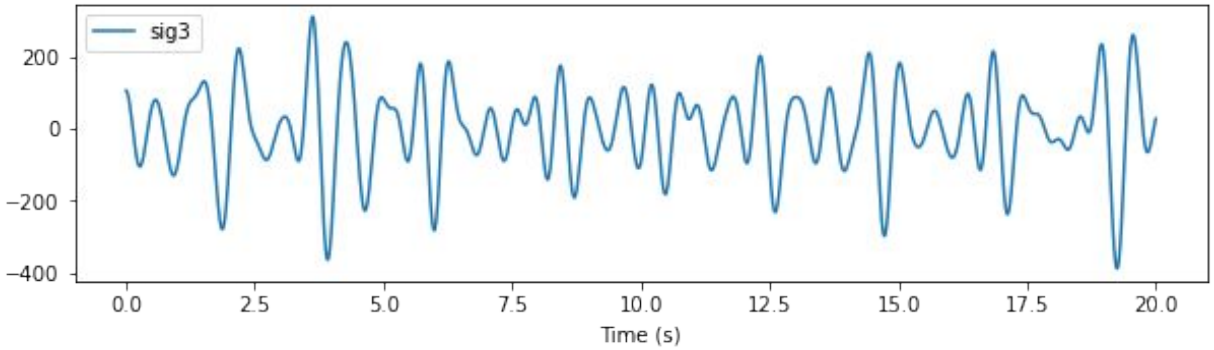
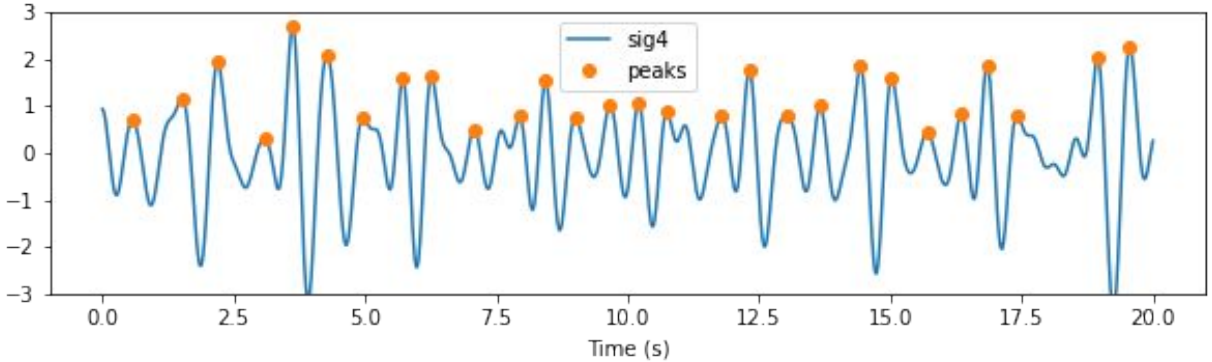
sig4 = (sig3 - sig3.mean()) / sig3.std()
peaks, _ = signal.find_peaks(sig4, prominence=0.5)
```





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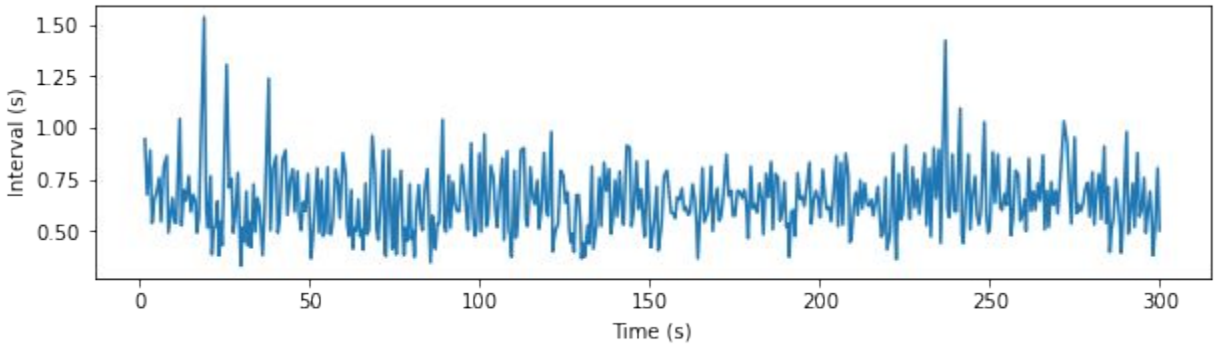

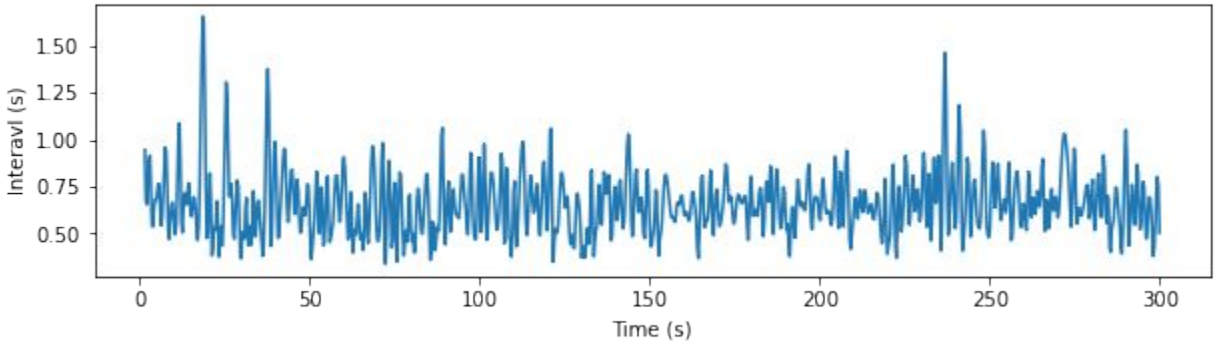

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range_vlf = range(r_vlf[0], r_vlf[1]+1)
range_hf = range(r_hf[0], r_hf[1]+1)
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LF_power = s_psd[range_lf].sum() * f_step * 1000000
HF_power = s_psd[range_hf].sum() * f_step * 1000000
LF_HF = LF_power / HF_power

LF_peak = s_freq[range_lf][np.argmax(s_psd[range_lf])]
HF_peak = s_freq[range_hf][np.argmax(s_psd[range_hf])]
```
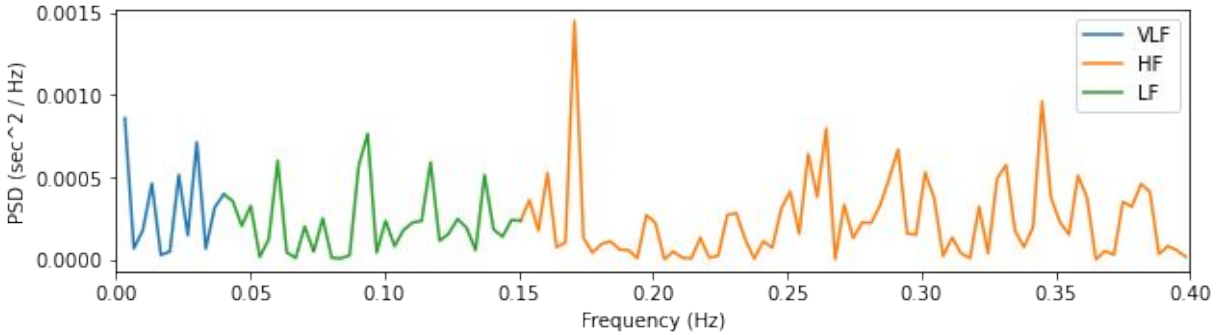

```
VLF power :  978.415 ms^2
LF power  : 1969.741 ms^2
HF power  : 4602.487 ms^2
LF peak   :    0.094 Hz
HF peak   :    0.171 Hz
LF/HF     :    0.428
```



References

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5624990/
(An Overview of Heart Rate Variability Metrics and Norms)

https://www.ahajournals.org/doi/10.1161/01.CIR.93.5.1043
(Standards of Measurement, Physiological Interpretation, and Clinical Use)