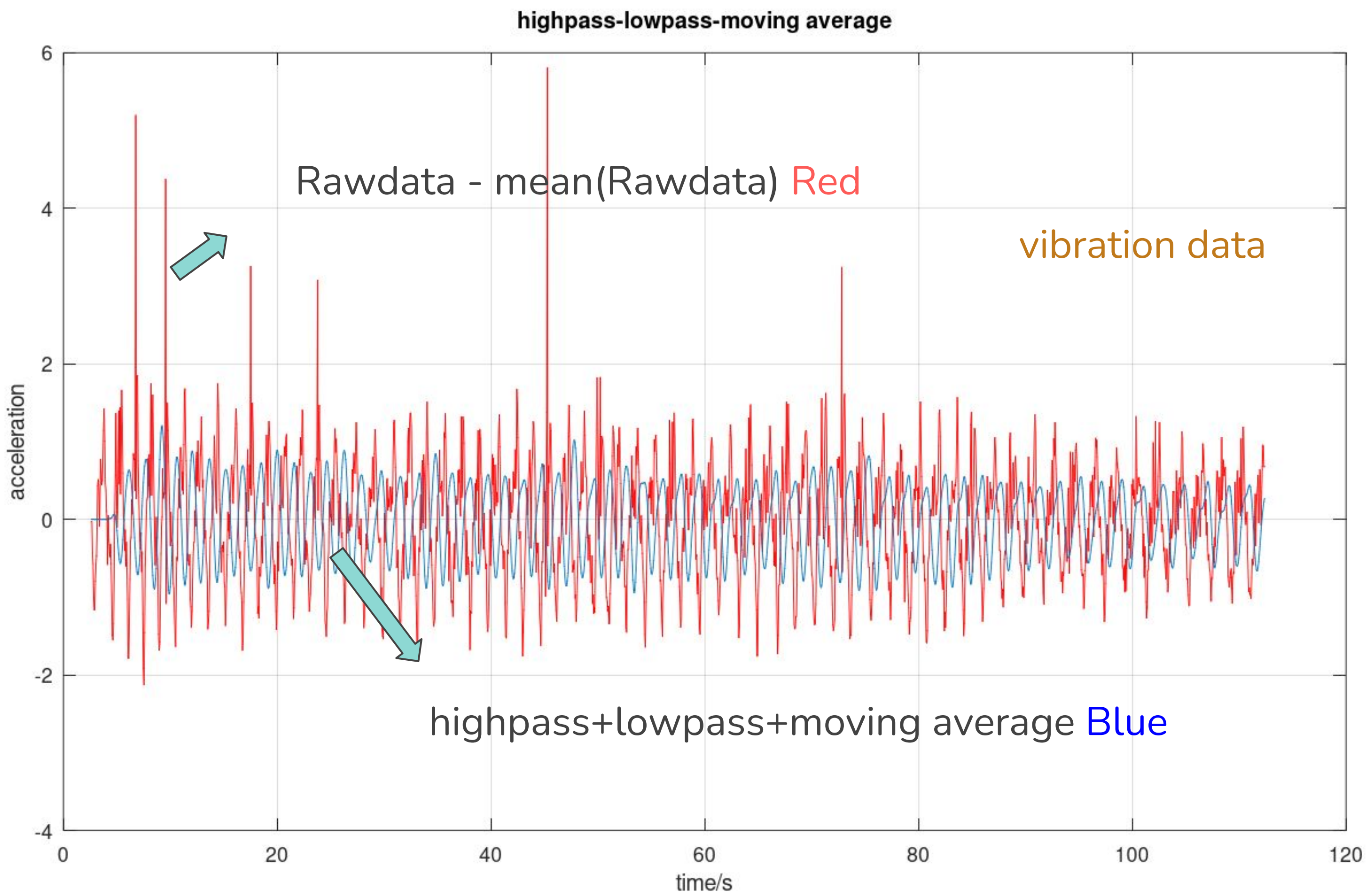
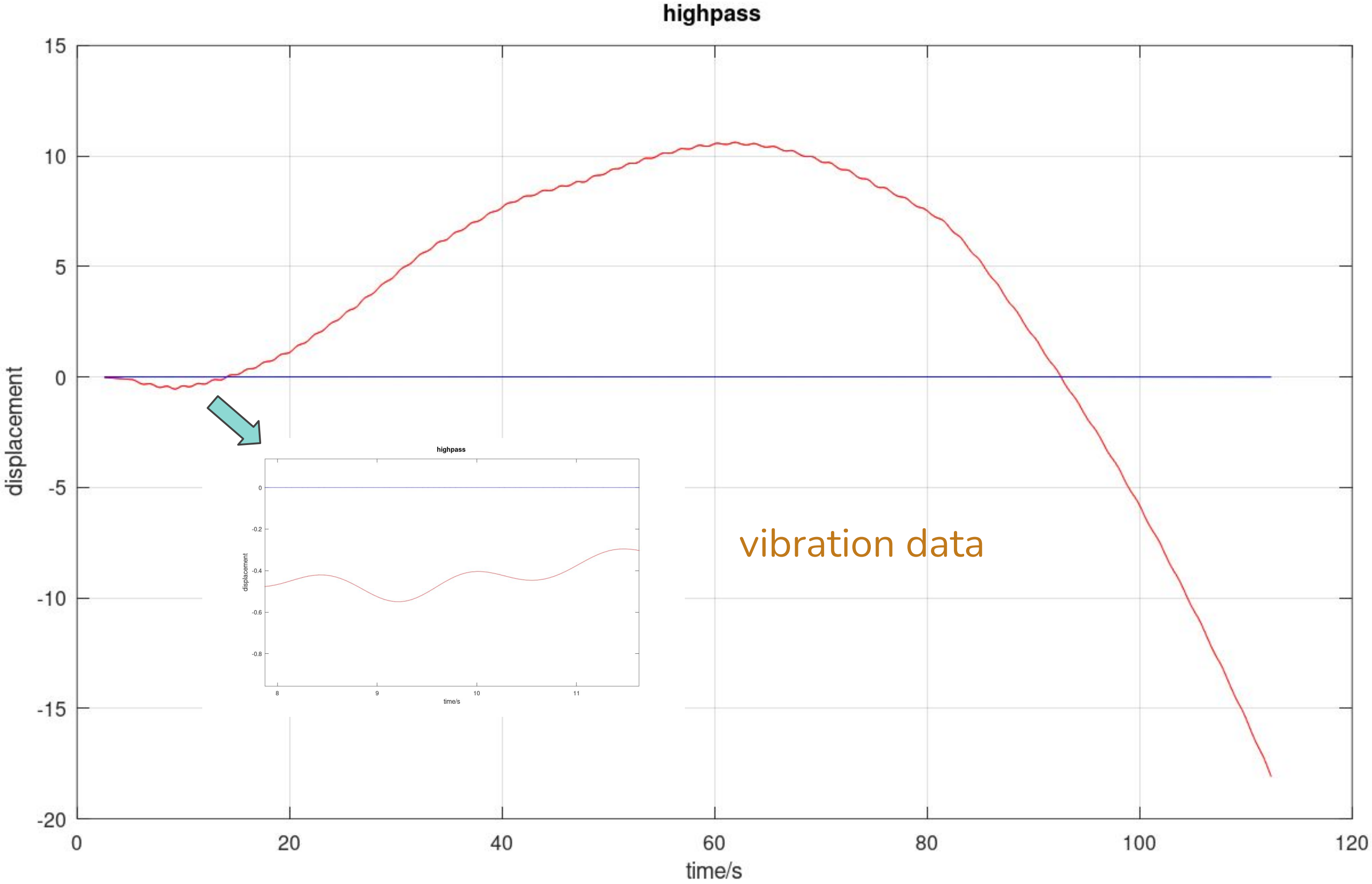
状況報告:
MURON

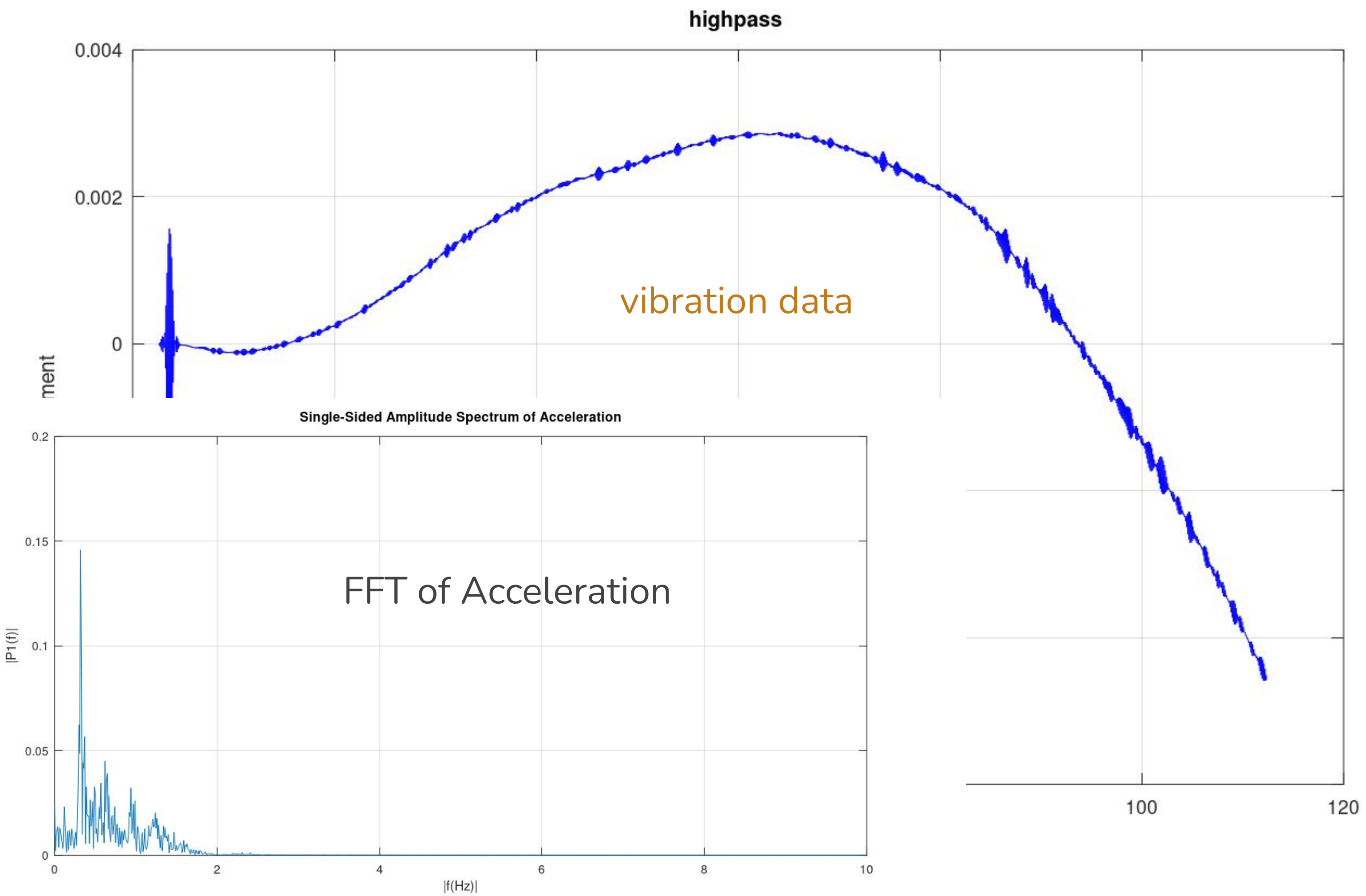
Xuanda Feng • 2021 年 9 月 10 日

Highpass Filter



highpass-lowpass-moving average
Rawdata - mean(Rawdata) Red
vibration data
highpass+lowpass+moving average Blue
acceleration
time/s
6
4
2
0
-2
-4
0
20
40
60
80
100
120

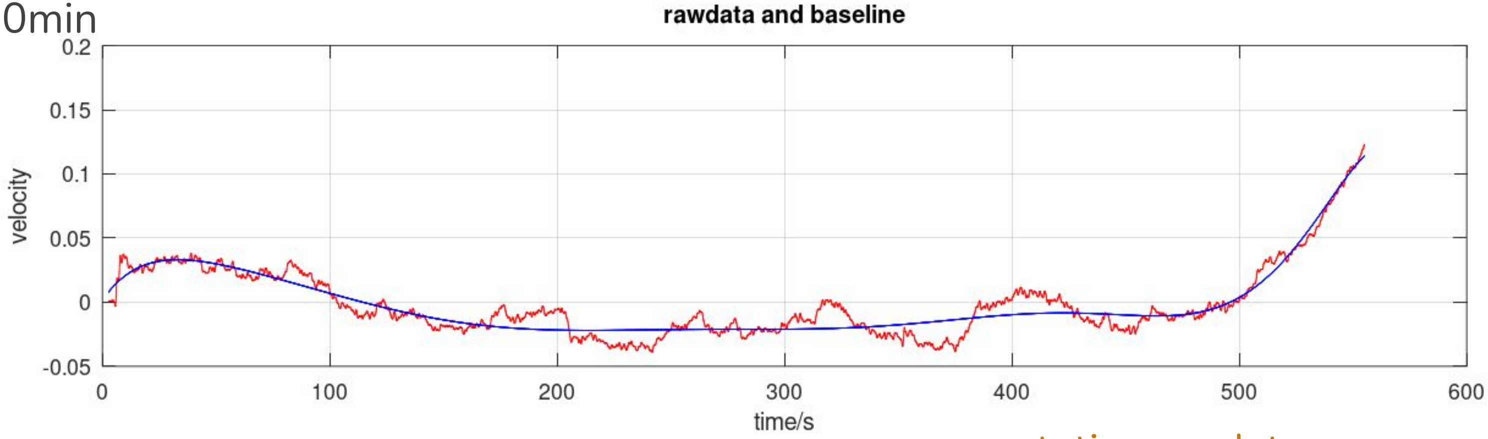

highpass
displacement
time/s
15
10
5
0
-5
-10
-15
-20
0
20
40
60
80
100
120
highpass
displacement
time/s
0
-0.2
-0.4
-0.6
-0.8
8
9
10
11
vibration data


highpass
0.004
0.002
0
ment
vibration data
100
120
Single-Sided Amplitude Spectrum of Acceleration
0.2
0.15
0.1
0.05
0
|P1(f)|
FFT of Acceleration
0
2
4
6
8
10
|f(Hz)|

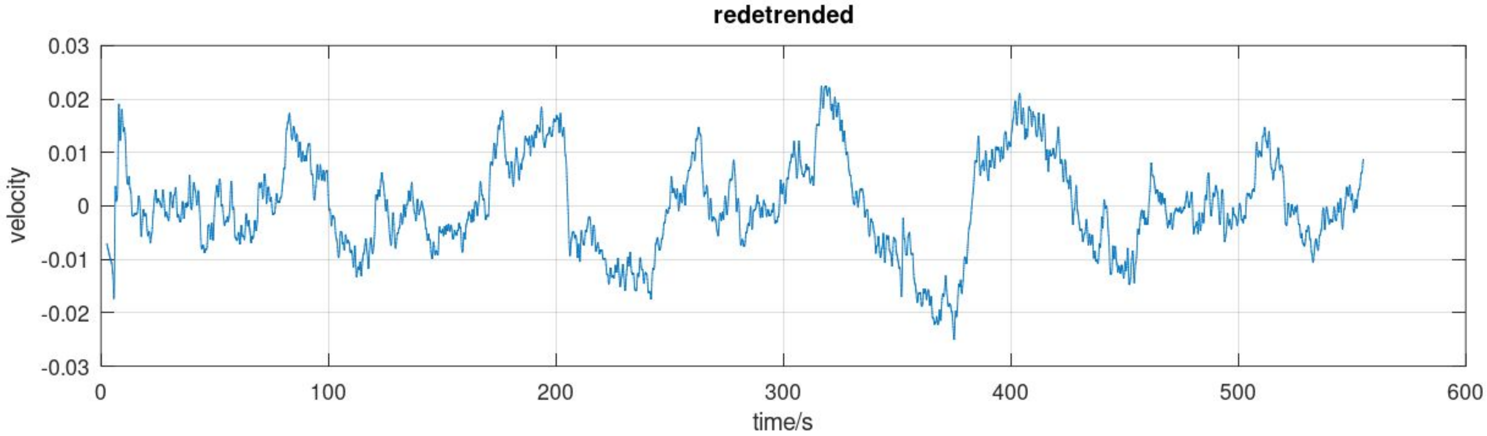
Polynomial Fitting

Number of orders: 5

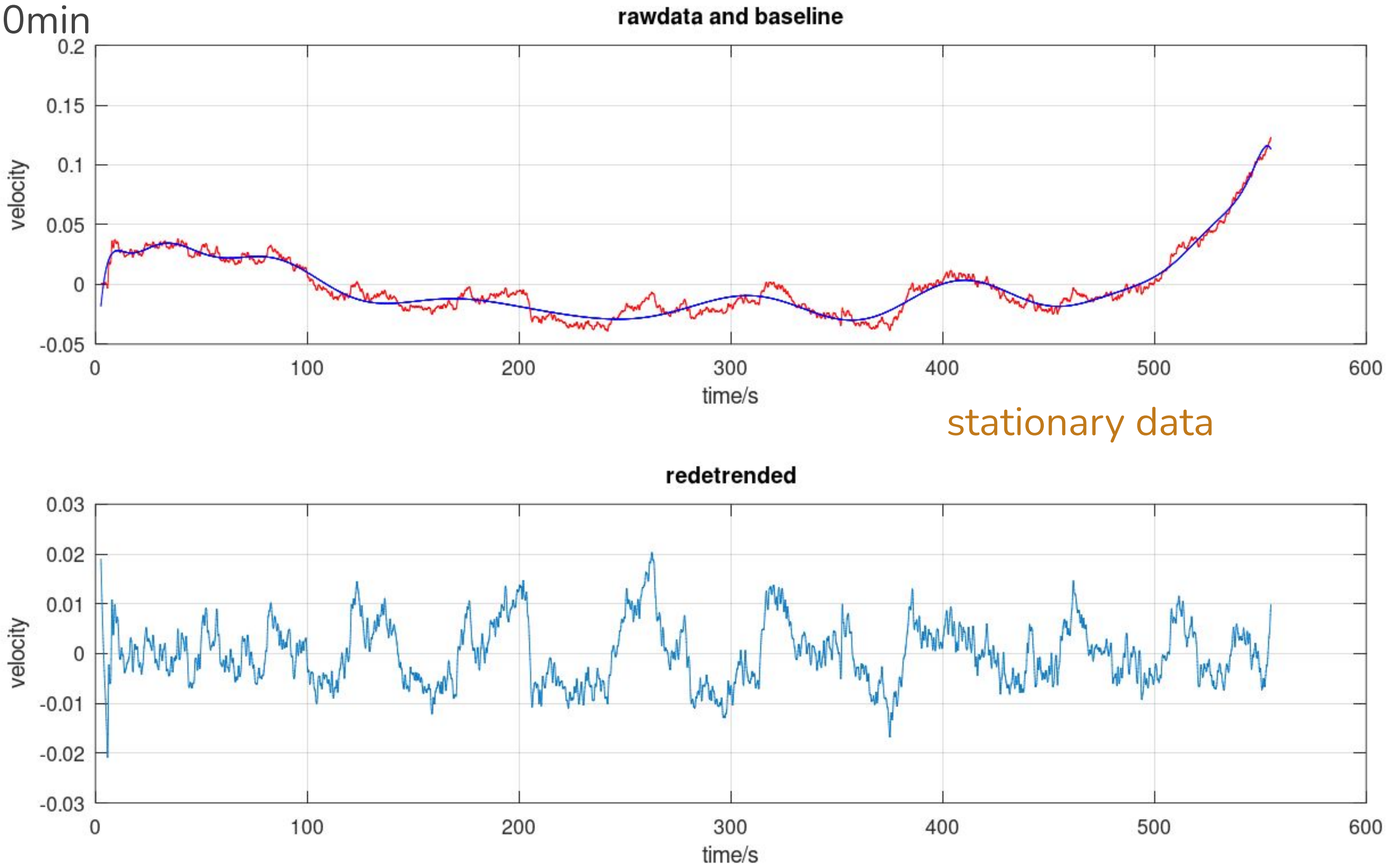
Time: 10min



stationary data

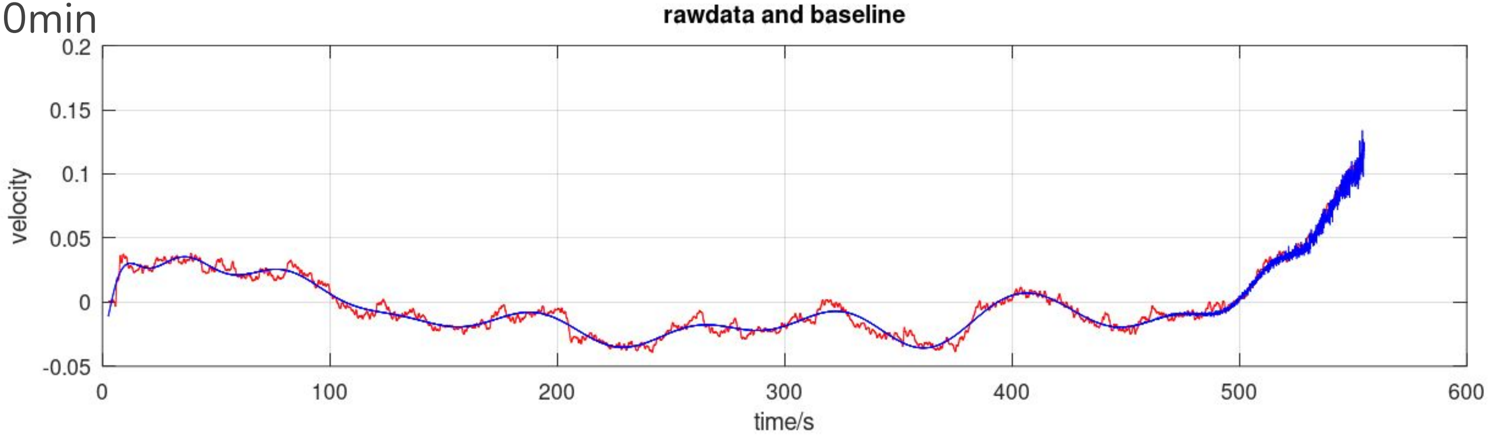


Number of orders: 10
Time: 10min



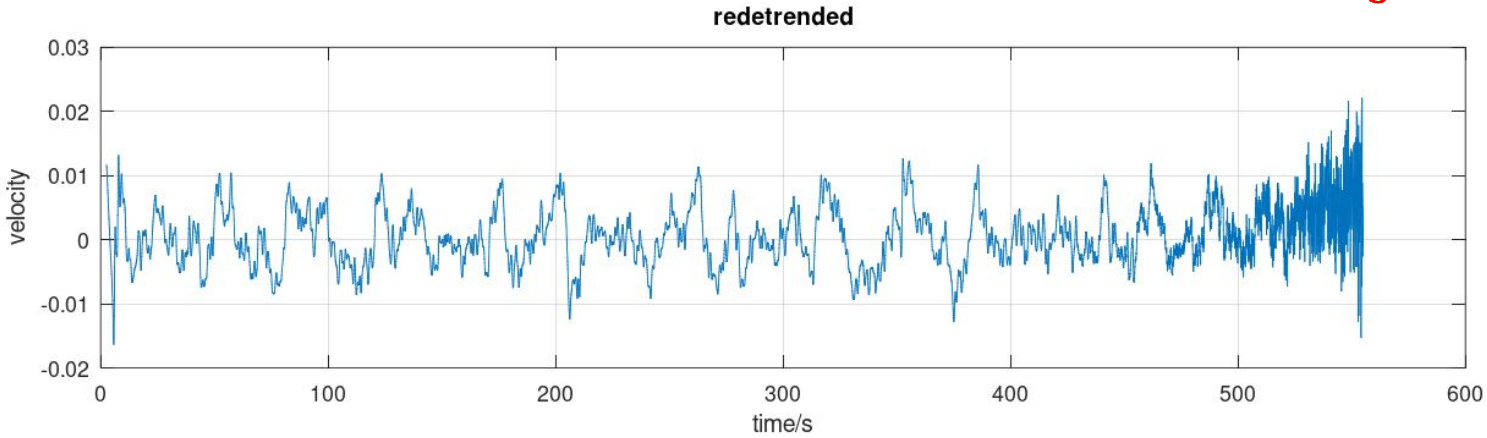
Number of orders: 20

Time: 10min



stationary data

Overfitting

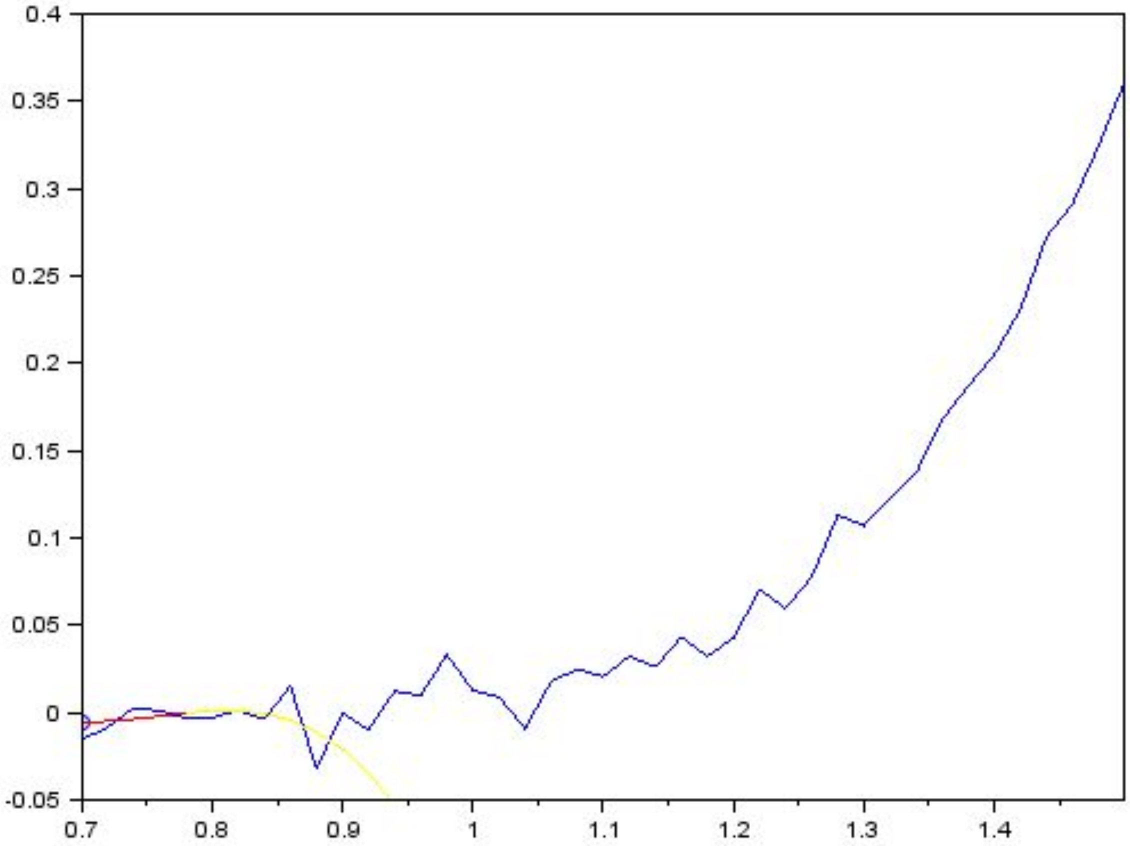


Savitzky-Golay Filter

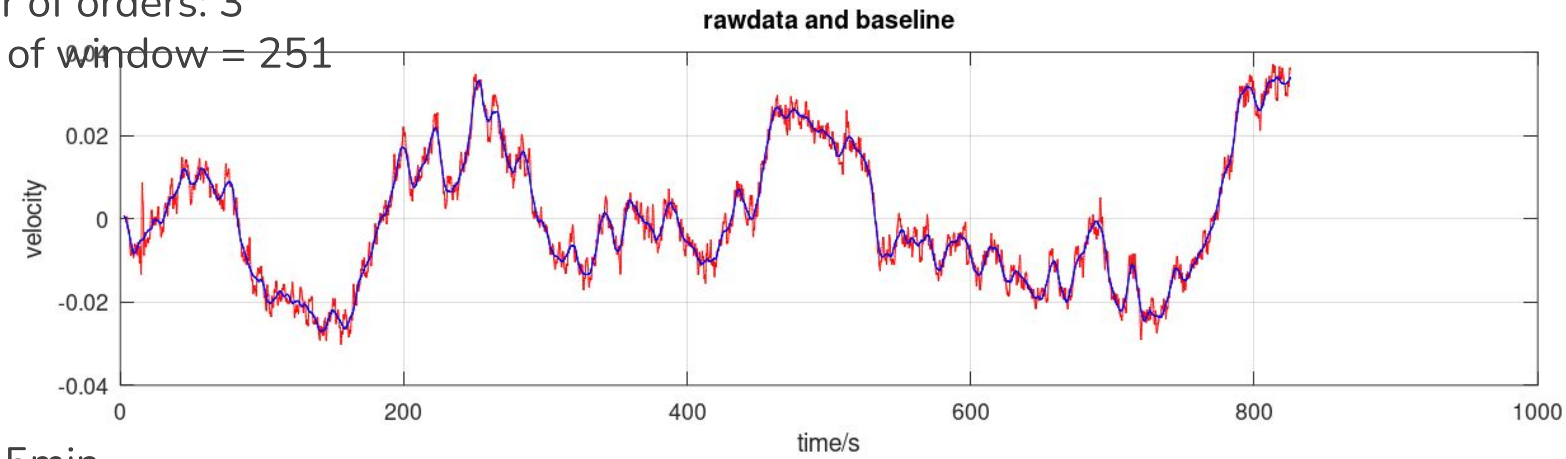
Moving Average + Polynomial Fitting (Least Square Method)

Tunable parameter:

1. length of fitting(red)
2. number of orders of polynomial(red + yellow)

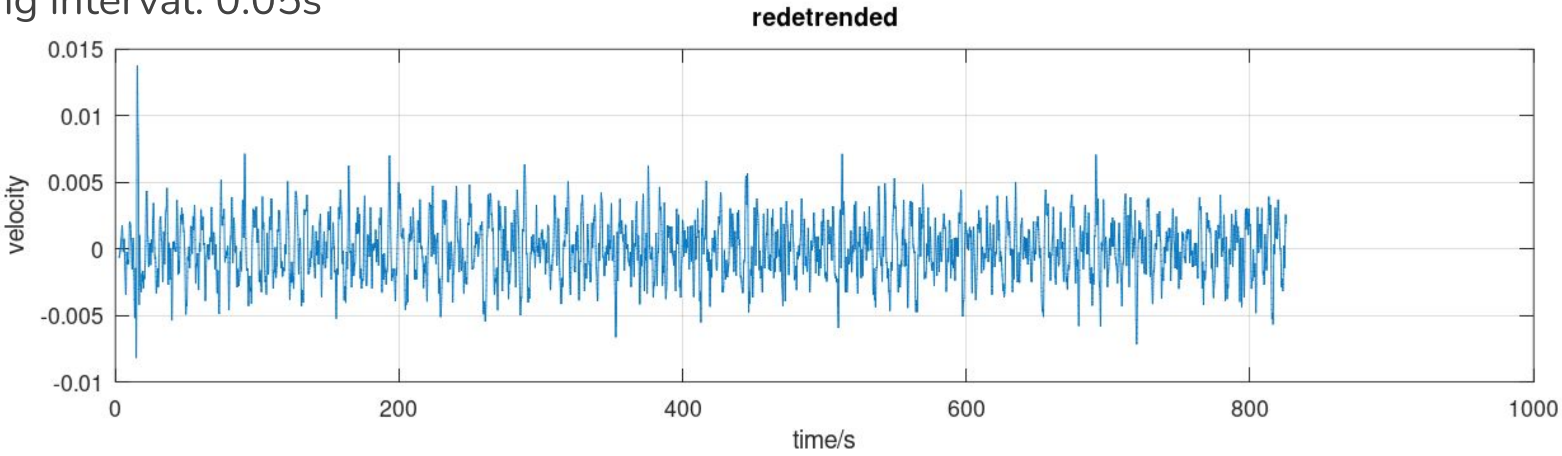


Number of orders: 3
Length of window = 251



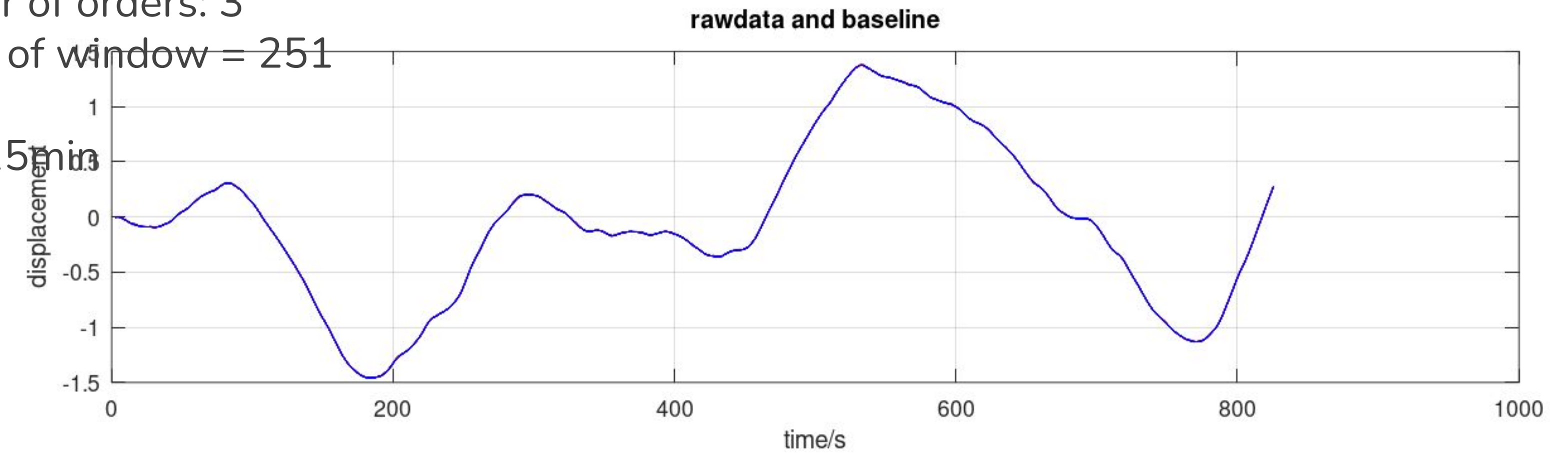
Time: 15min
Sampling interval: 0.05s

stationary data

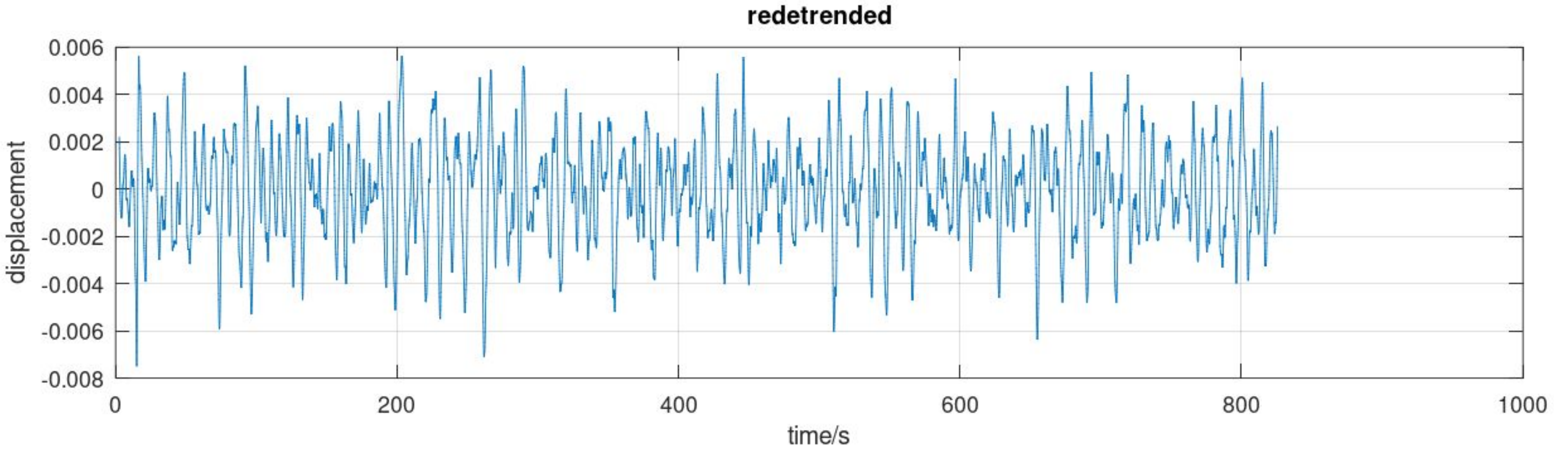


Number of orders: 3
Length of window = 251

Time: 15min

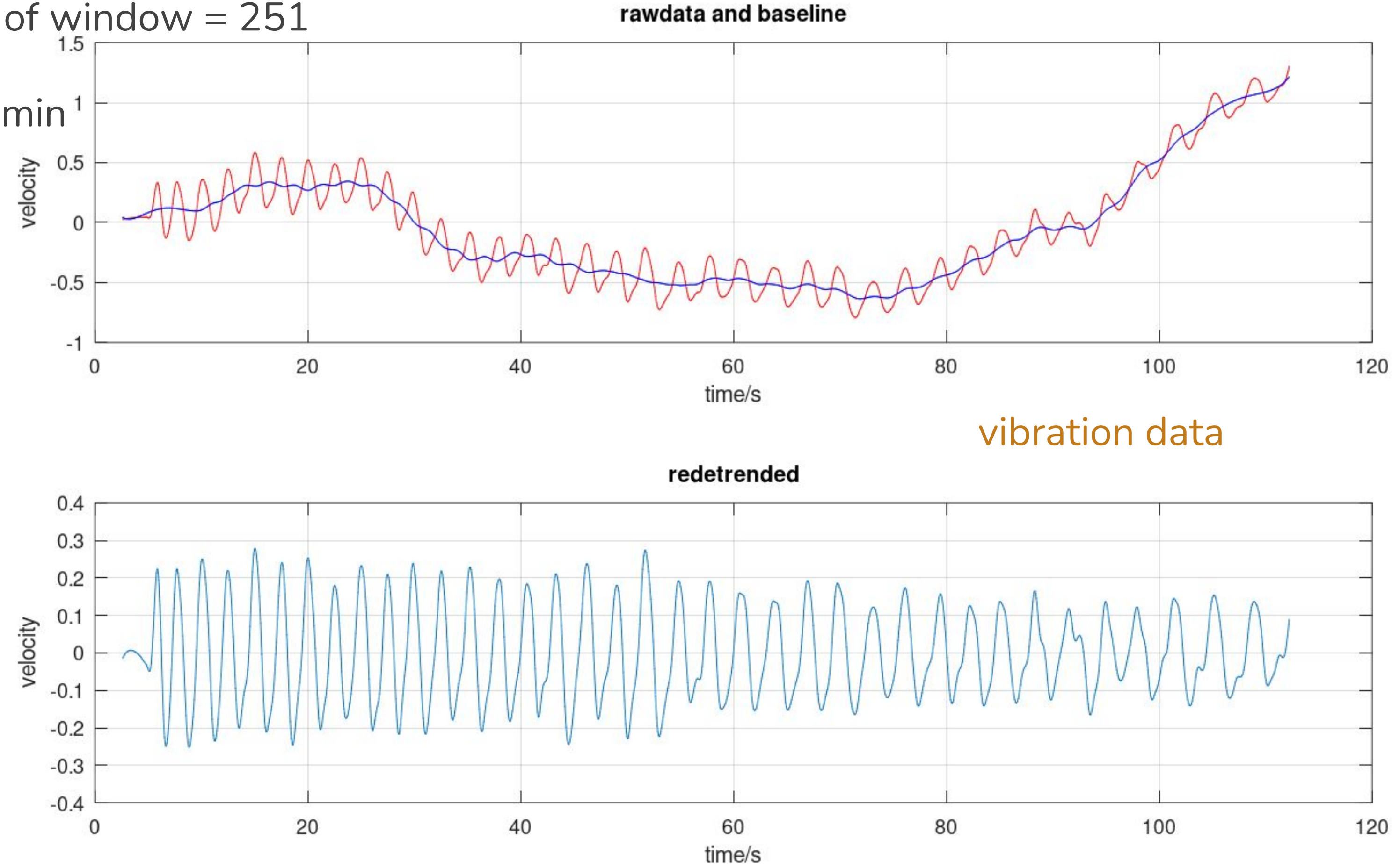


stationary data



Number of orders: **2**
Length of window = 251

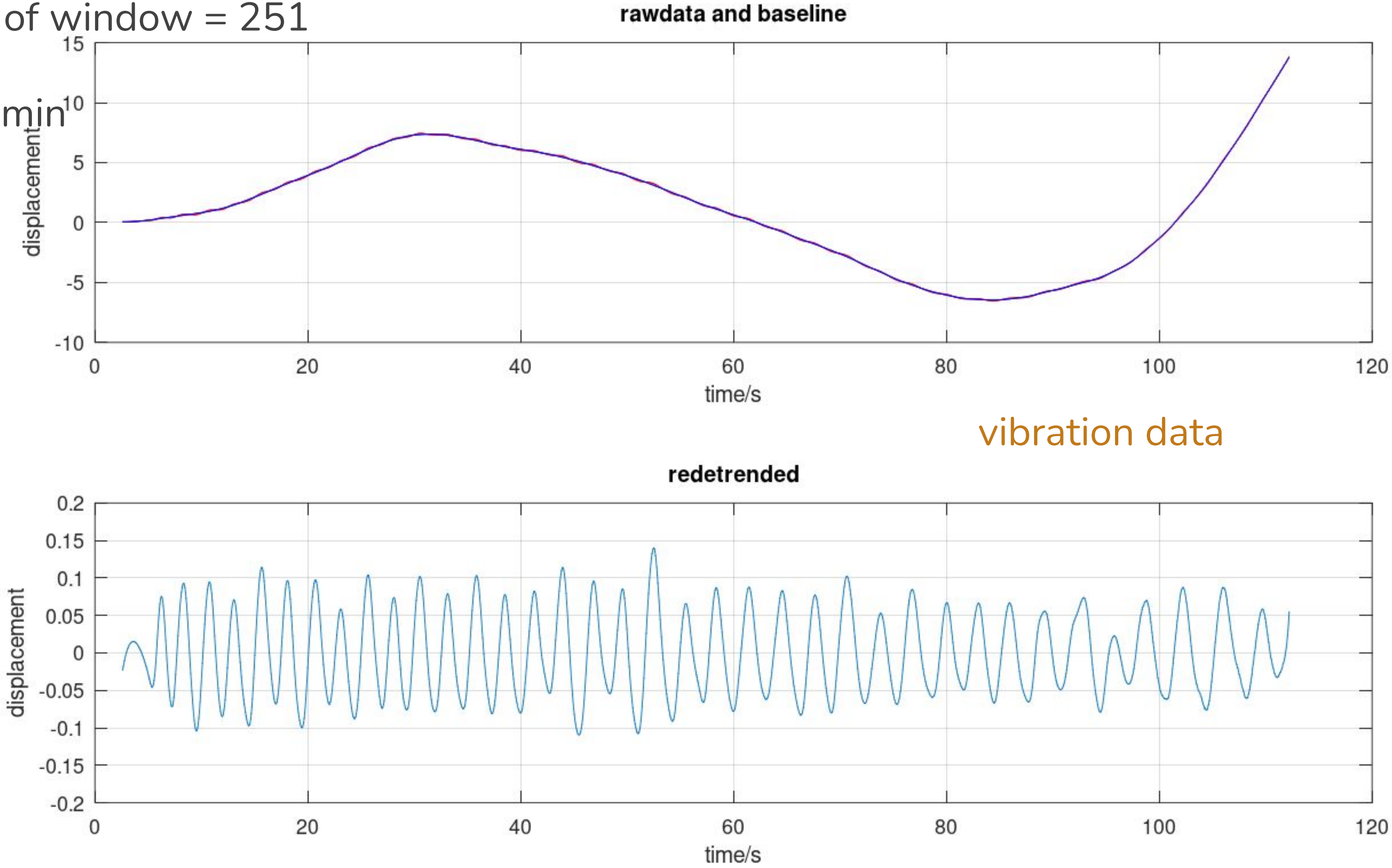
Time: 2min



vibration data

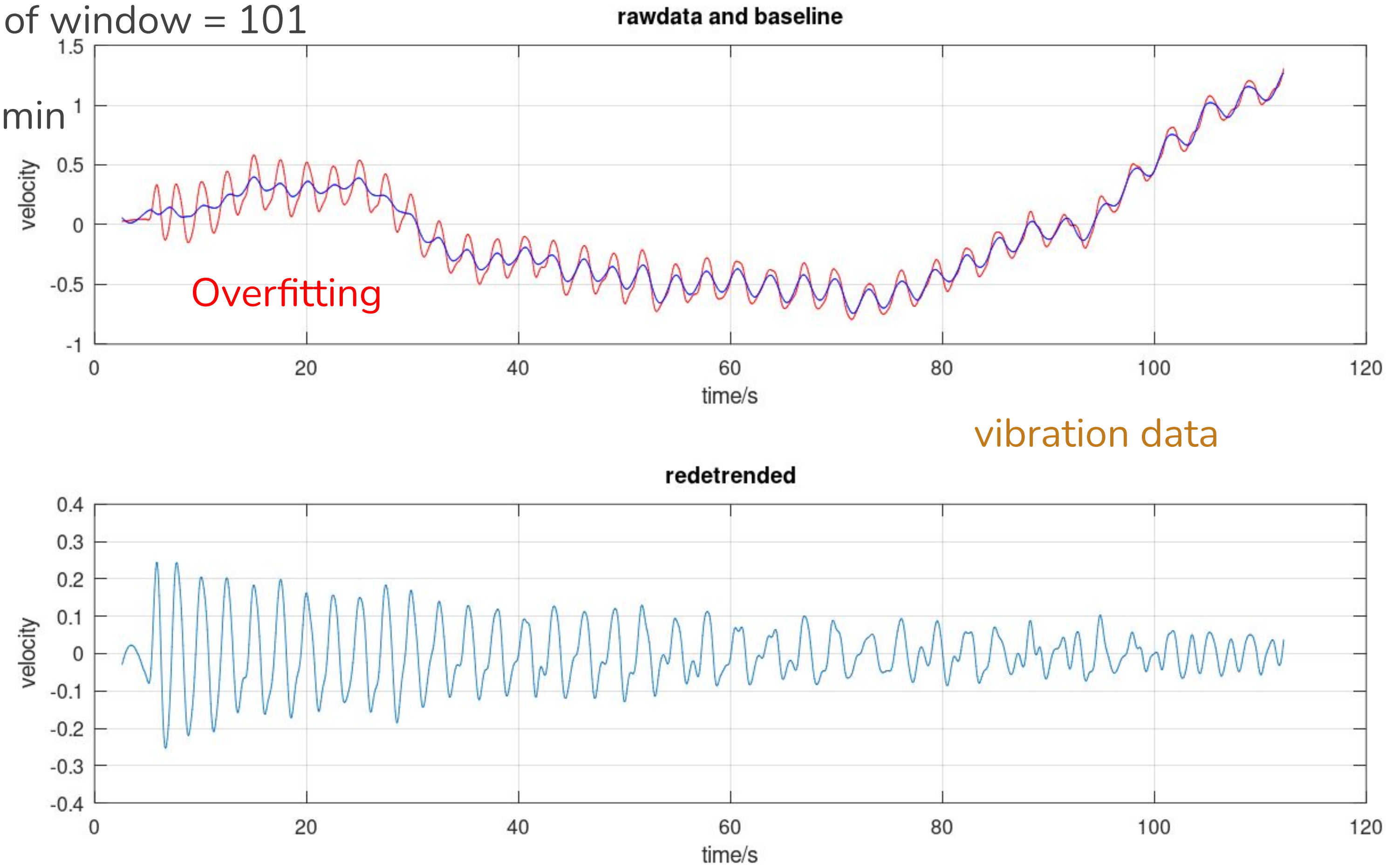
Number of orders: 2
Length of window = 251

Time: 2min



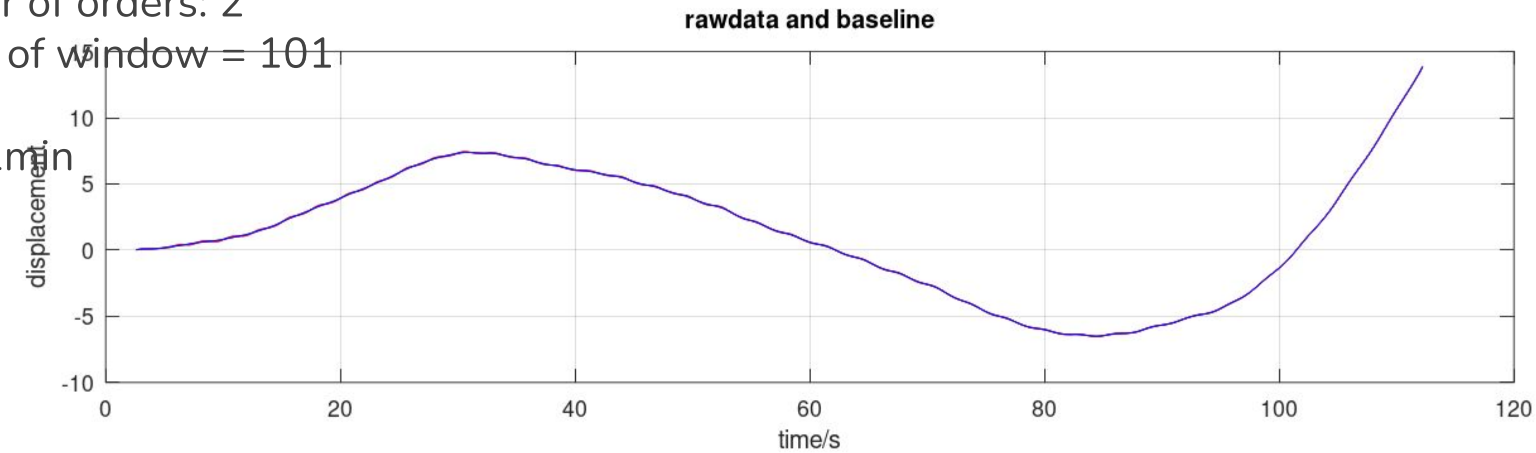
Number of orders: 2
Length of window = 101

Time: 2min

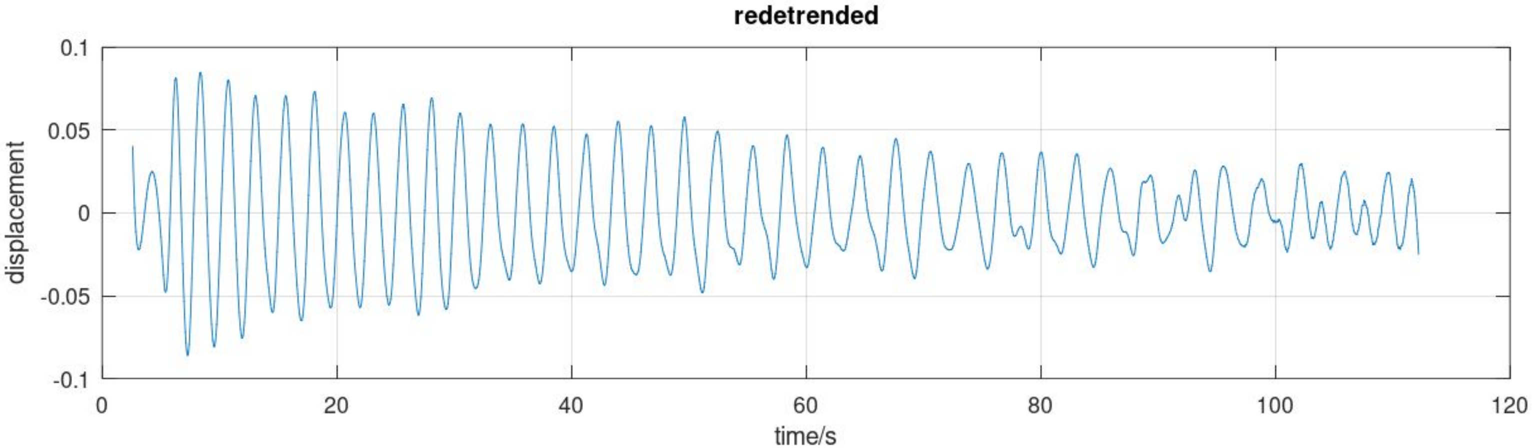


Number of orders: 2
Length of window = 101

Time: 2min

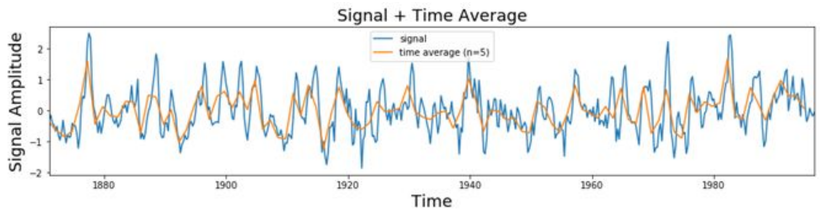


vibration data

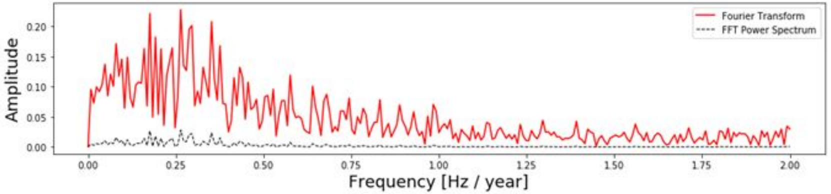


Wavelet Decomposition

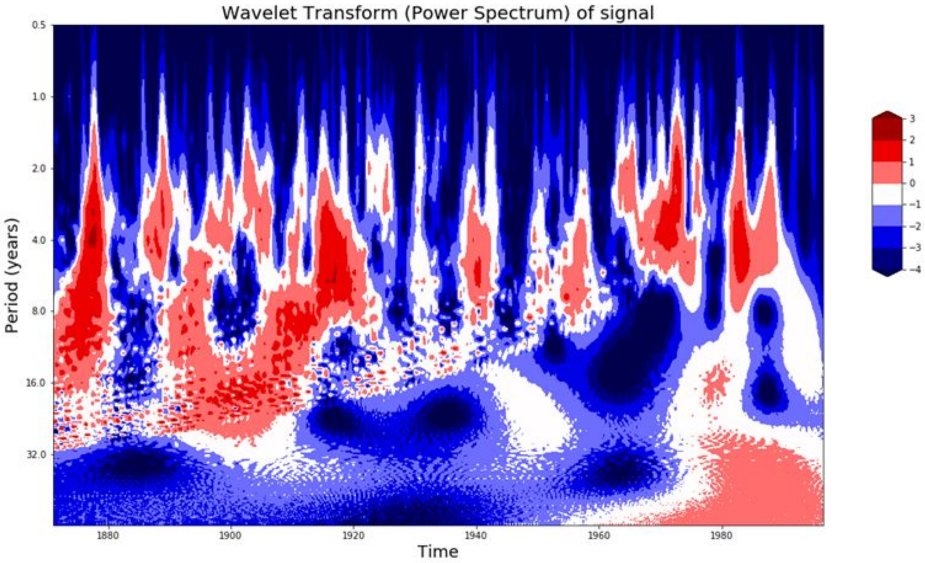
Signal

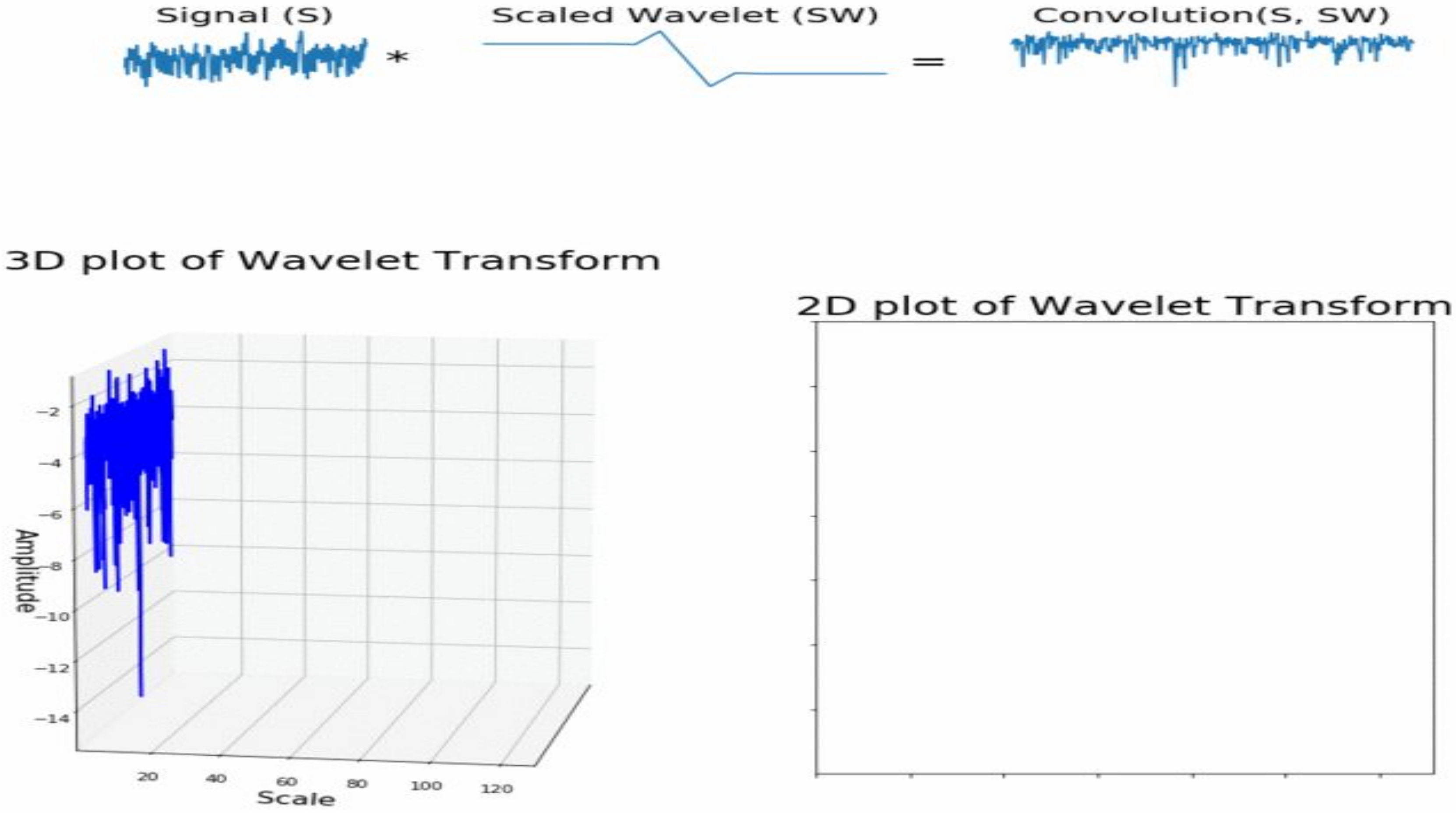


Fourier Transformation



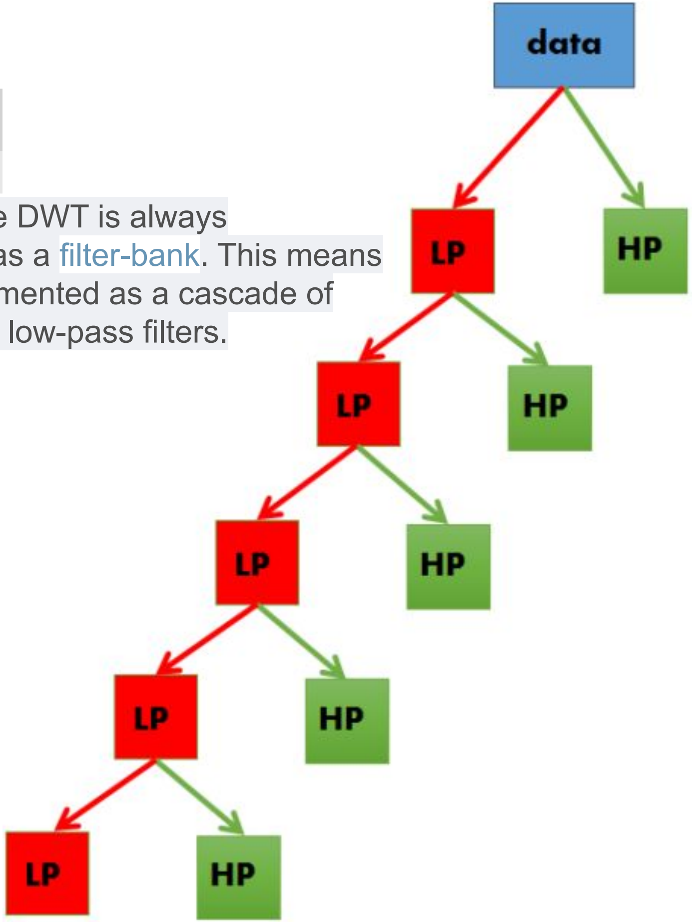
Wavelet Transformation

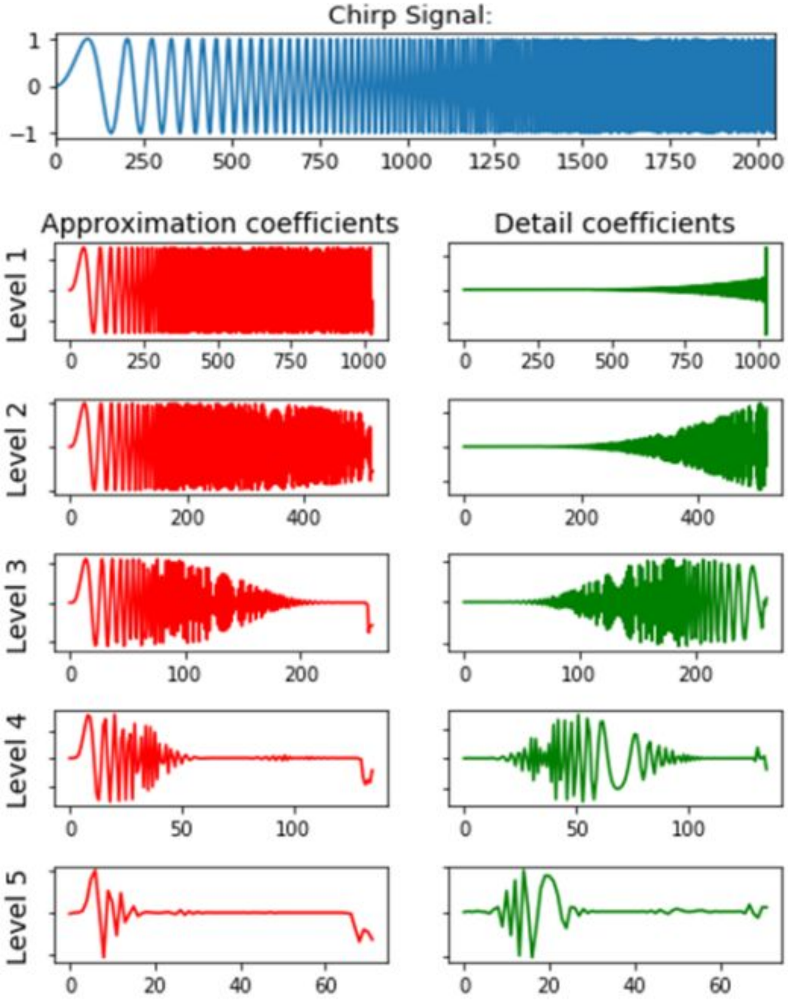


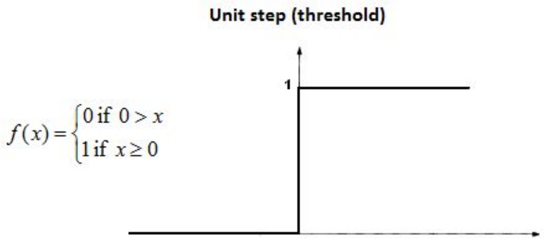


source: ataspinar.com

In practice, the DWT is always implemented as a filter-bank. This means that it is implemented as a cascade of high-pass and low-pass filters.







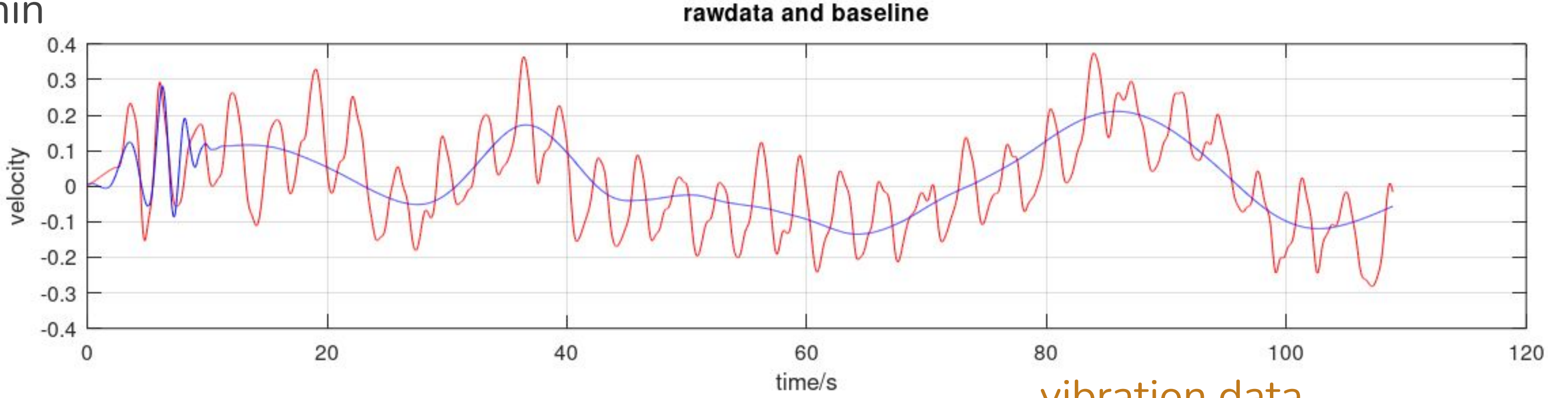
Signal → Wavelet Transform → Thresh Function → Inverse Wavelet Transform → Baseline

Tunable parameter:

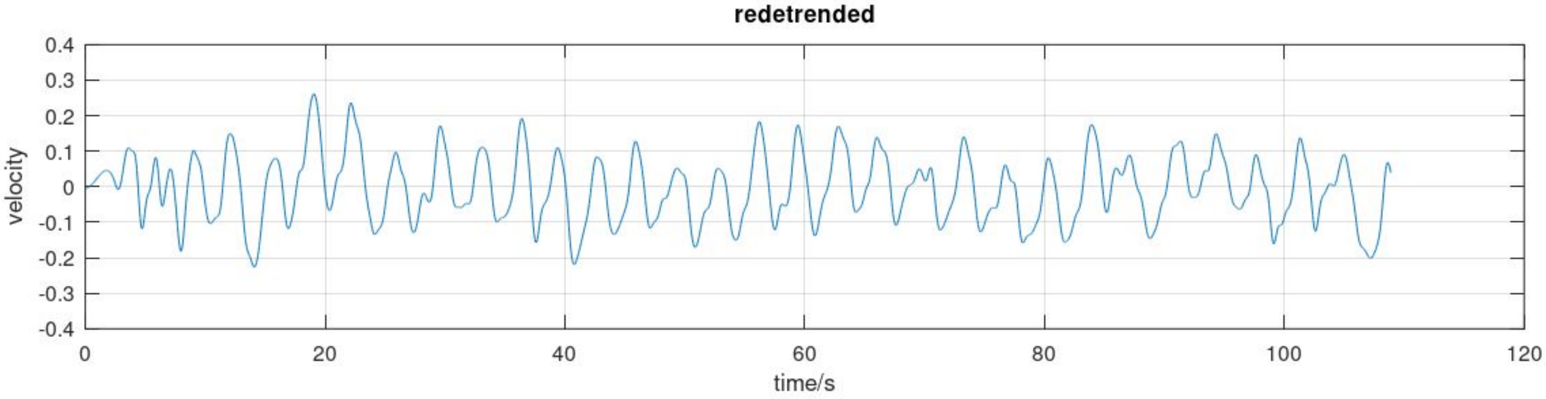
1. wavelet type
2. order of filter_bank
3. threshold value

wavelet: db8
iteration: 10

Time: 2min

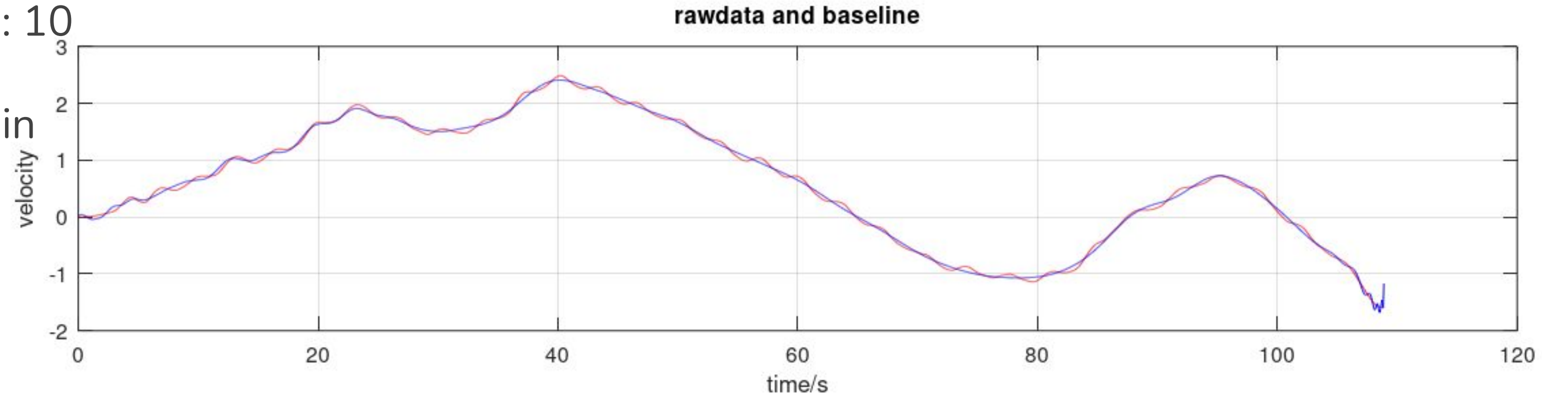


vibration data

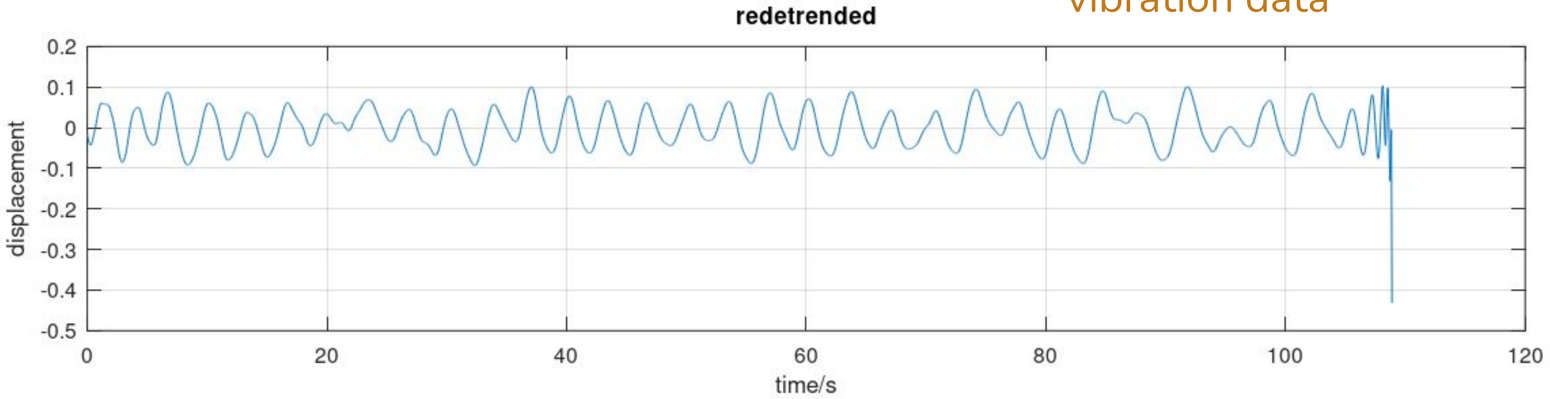


wavelet: db8
iteration: 10

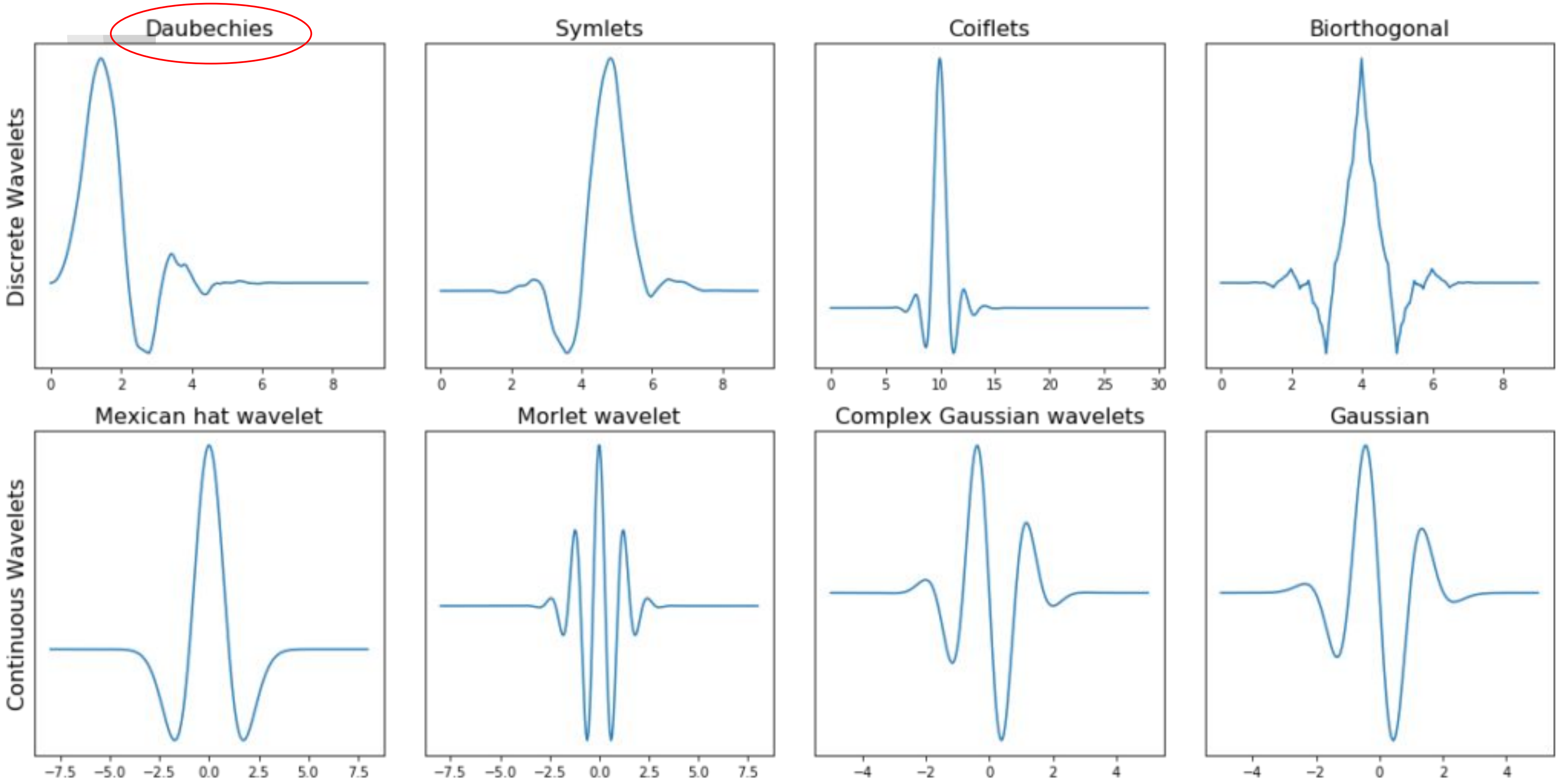
Time: 2min

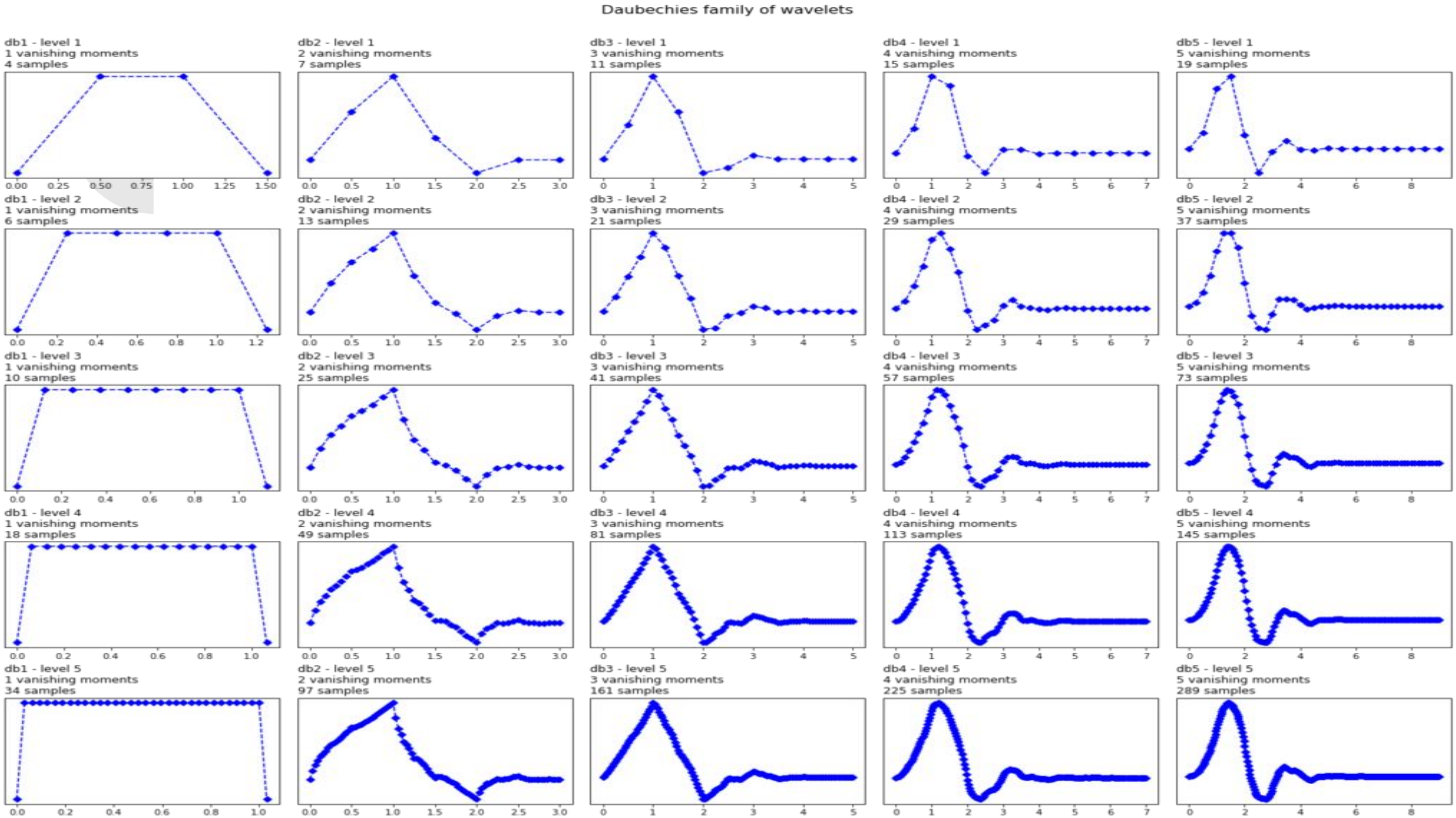


vibration data



Wavelets Families




Daubechies family of wavelets
db1 - level 1
1 vanishing moments
4 samples
db2 - level 1
2 vanishing moments
7 samples
db3 - level 1
3 vanishing moments
11 samples
db4 - level 1
4 vanishing moments
15 samples
db5 - level 1
5 vanishing moments
19 samples
db1 - level 2
1 vanishing moments
6 samples
db2 - level 2
2 vanishing moments
13 samples
db3 - level 2
3 vanishing moments
21 samples
db4 - level 2
4 vanishing moments
29 samples
db5 - level 2
5 vanishing moments
37 samples
db1 - level 3
1 vanishing moments
10 samples
db2 - level 3
2 vanishing moments
25 samples
db3 - level 3
3 vanishing moments
41 samples
db4 - level 3
4 vanishing moments
57 samples
db5 - level 3
5 vanishing moments
73 samples
db1 - level 4
1 vanishing moments
18 samples
db2 - level 4
2 vanishing moments
49 samples
db3 - level 4
3 vanishing moments
81 samples
db4 - level 4
4 vanishing moments
113 samples
db5 - level 4
5 vanishing moments
145 samples
db1 - level 5
1 vanishing moments
34 samples
db2 - level 5
2 vanishing moments
97 samples
db3 - level 5
3 vanishing moments
161 samples
db4 - level 5
4 vanishing moments
225 samples
db5 - level 5
5 vanishing moments
289 samples

Octave: [c,info] = fwt(...);

c: Amplitude Coefficient (1-d vector)

Selection of Threshold Value

Syntax

```
THR = thselect(X,TPTR)
```

Description

`THR = thselect(X,TPTR)` returns the threshold value adapted to the 1-D signal X using the selection rule specified by TPTR. Available selection rules are:

- `'rigrsure'` — Adaptive threshold selection using the principle of Stein's Unbiased Risk Estimate (SURE).
- `'sqtwolog'` — Fixed-form threshold is `sqrt(2*log(length(X)))`.
- `'heursure'` — Heuristic variant of `'rigrsure'` and `'sqtwolog'`.
- `'minimaxi'` — Minimax thresholding.

Rule of Threshold Value

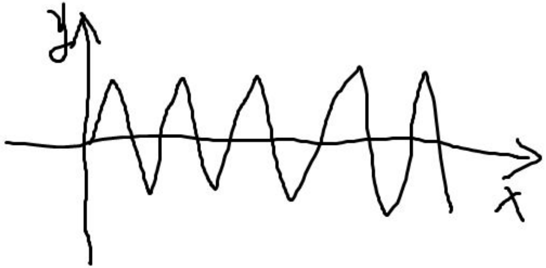
```
'hard'     Perform hard thresholding. This is the default.

'wiener'   Perform empirical Wiener shrinkage. This is in between
           soft and hard thresholding.

'soft'     Perform soft thresholding.
```

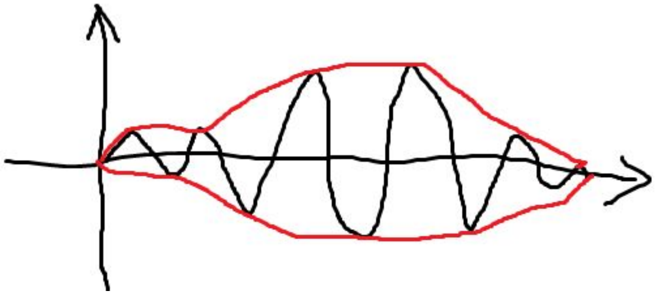
So why should you use the DWT instead? The advantage of the DWT again comes from the many wavelet shapes there are available. You can choose a wavelet which will have a shape characteristic to the phenomena you expect to see. In this way, less of the phenomena you expect to see will be smoothed out.

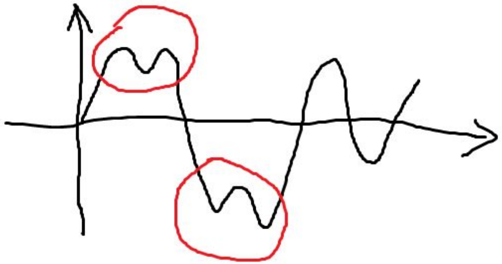
Empirical Mode Decomposition (EMD)

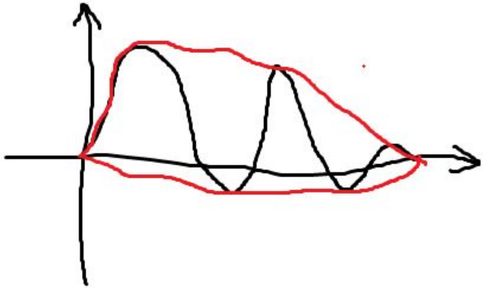
Intrinsic Mode Functions, IMF

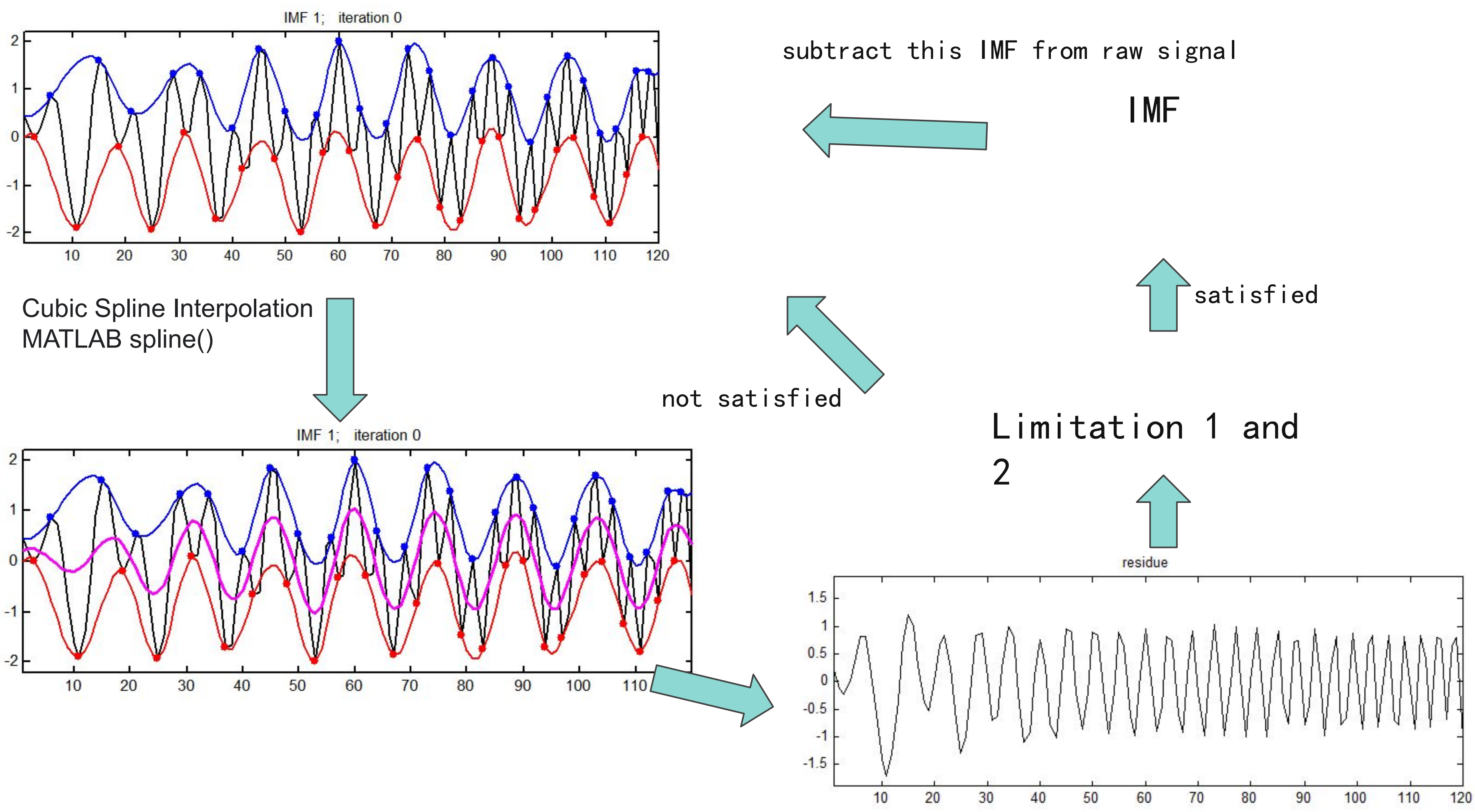
1. In the whole data set, the number of extrema and the number of zero-crossings must either be equal or differ at most by one.
2. At any point, the mean value of the envelope defined by the local maxima and the envelope defined by the local minima is zero.

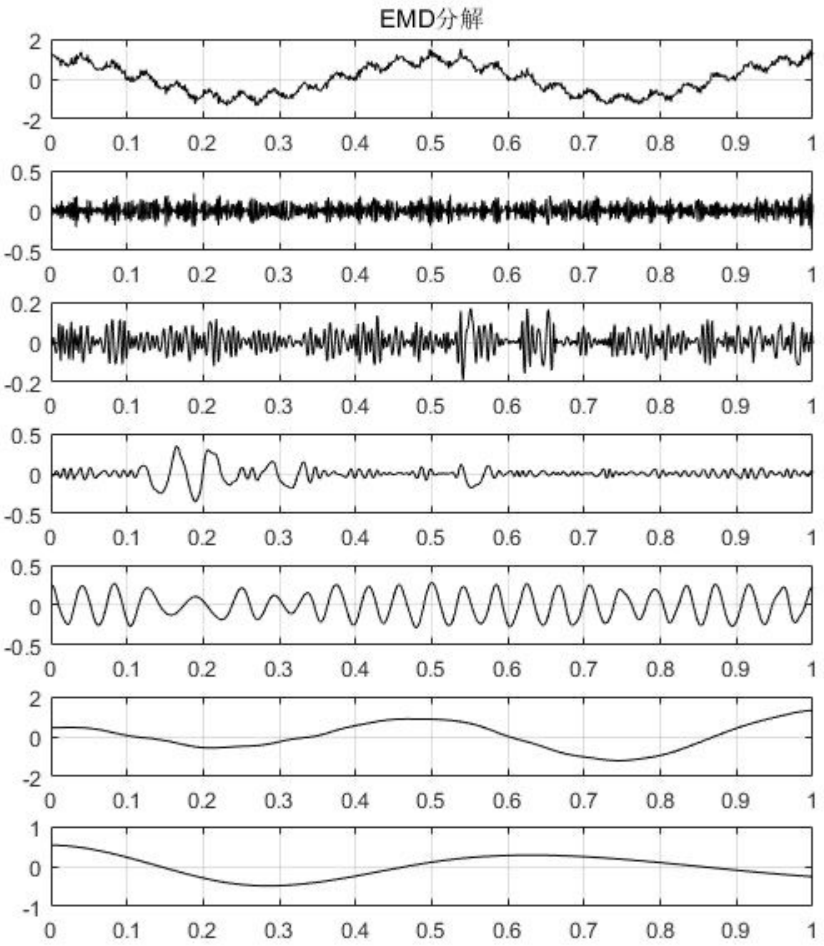









IMF 1; iteration 0
Cubic Spline Interpolation
MATLAB spline()
IMF 1; iteration 0
subtract this IMF from raw signal
IMF
satisfied
not satisfied
Limitation 1 and 2
residue



Vibration components

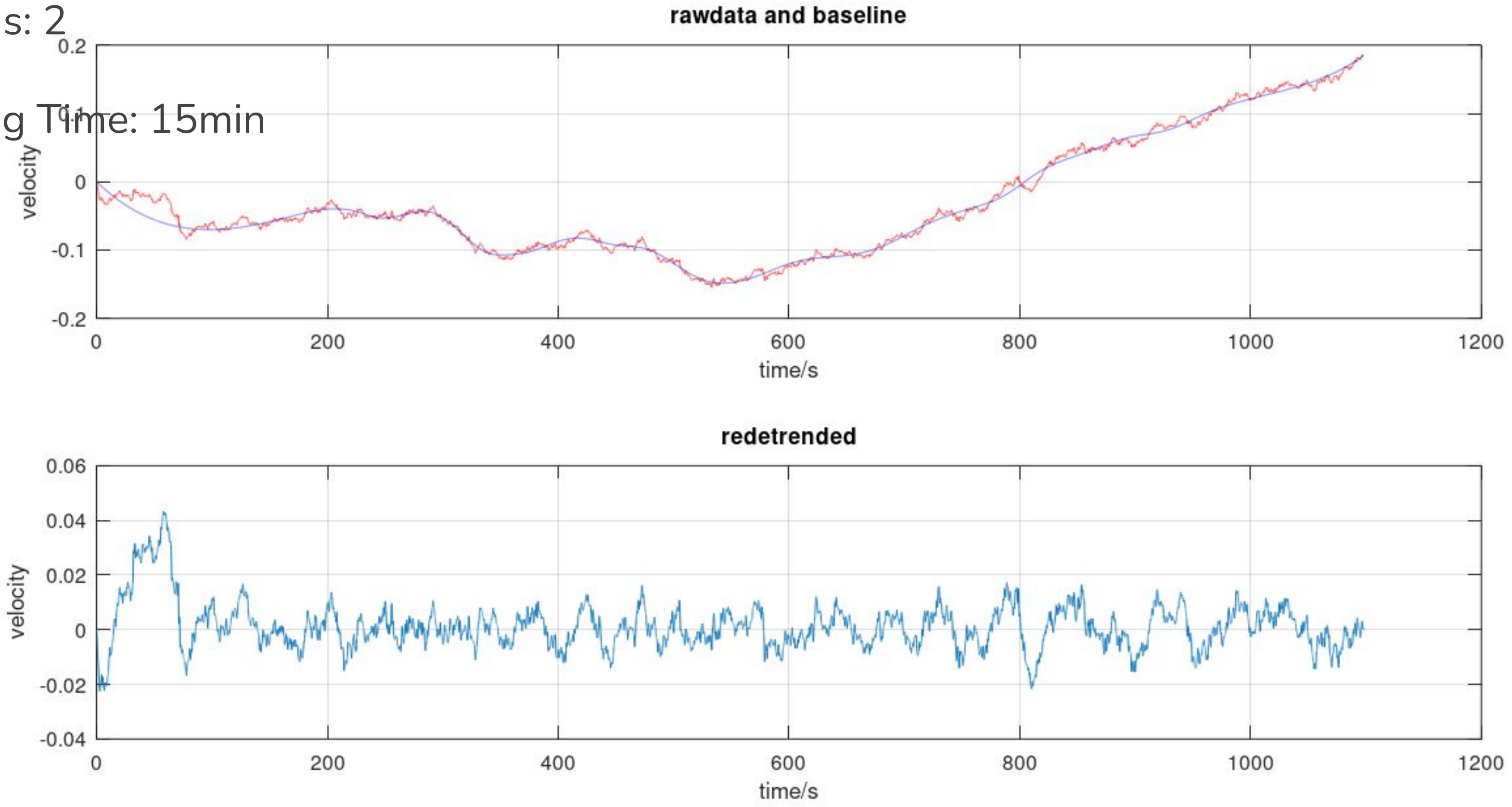
Random Walk

Stop Condition:

1. residue error
2. number of poles

Residue error: 0.03
iterations: 2

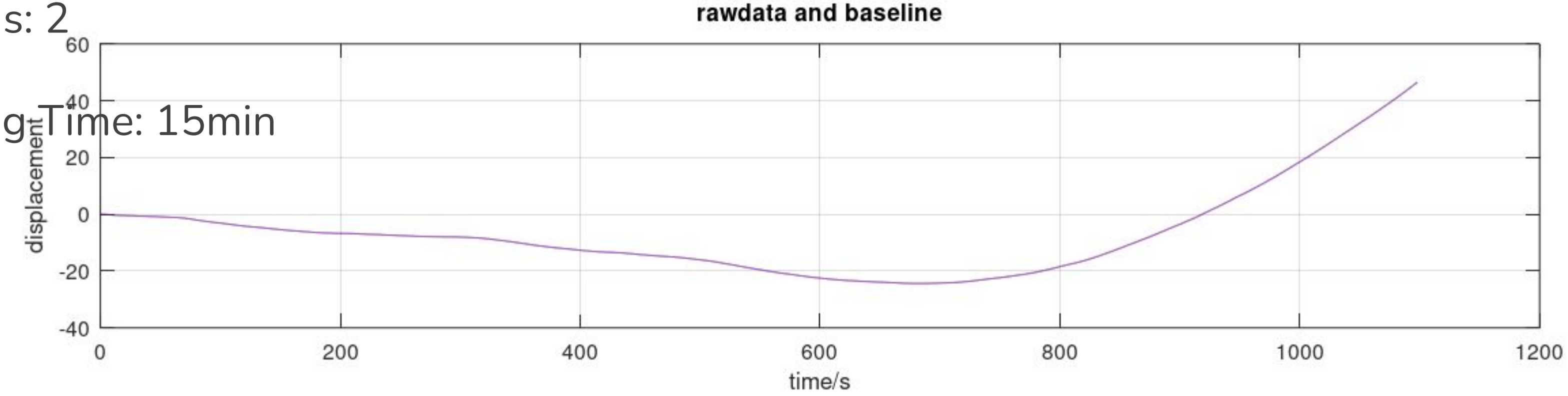
Sampling Time: 15min

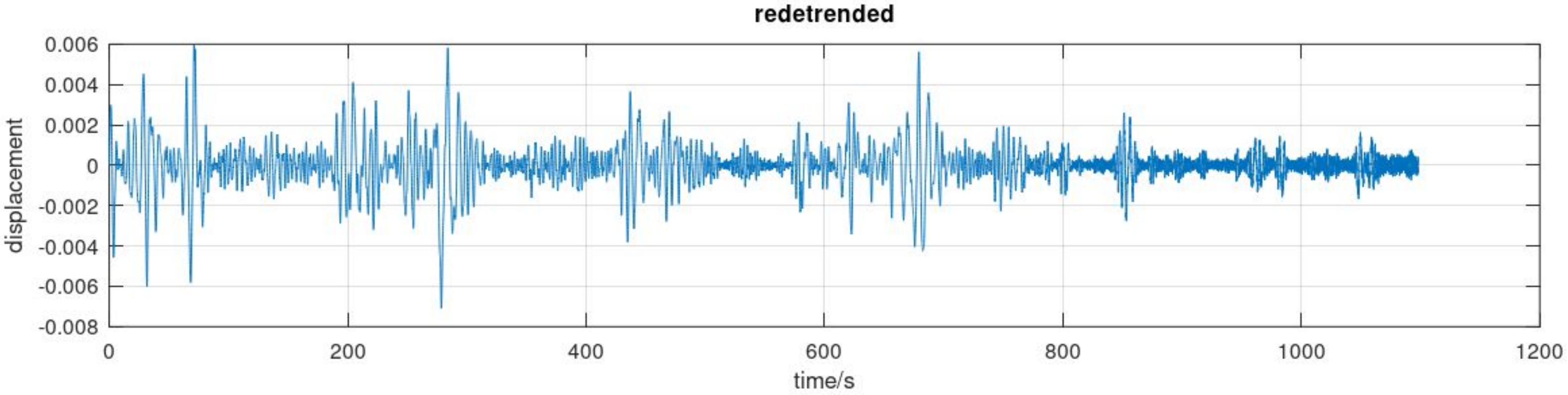


Calculation Time: 1h

Residue error: 0.3
iterations: 2

Sampling Time: 15min

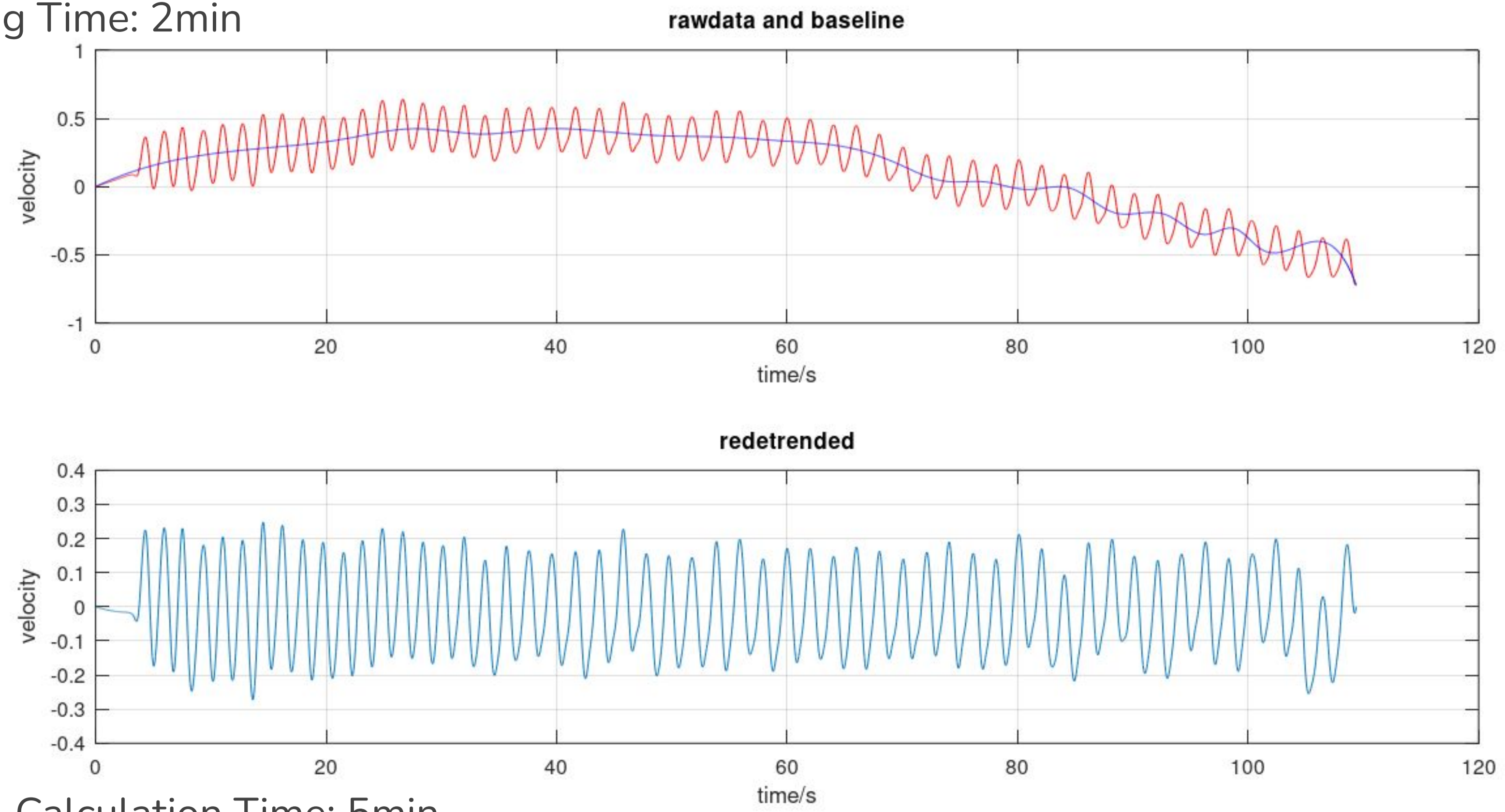




Calculation Time: 1h

Residue error: 0.03
iterations: 15

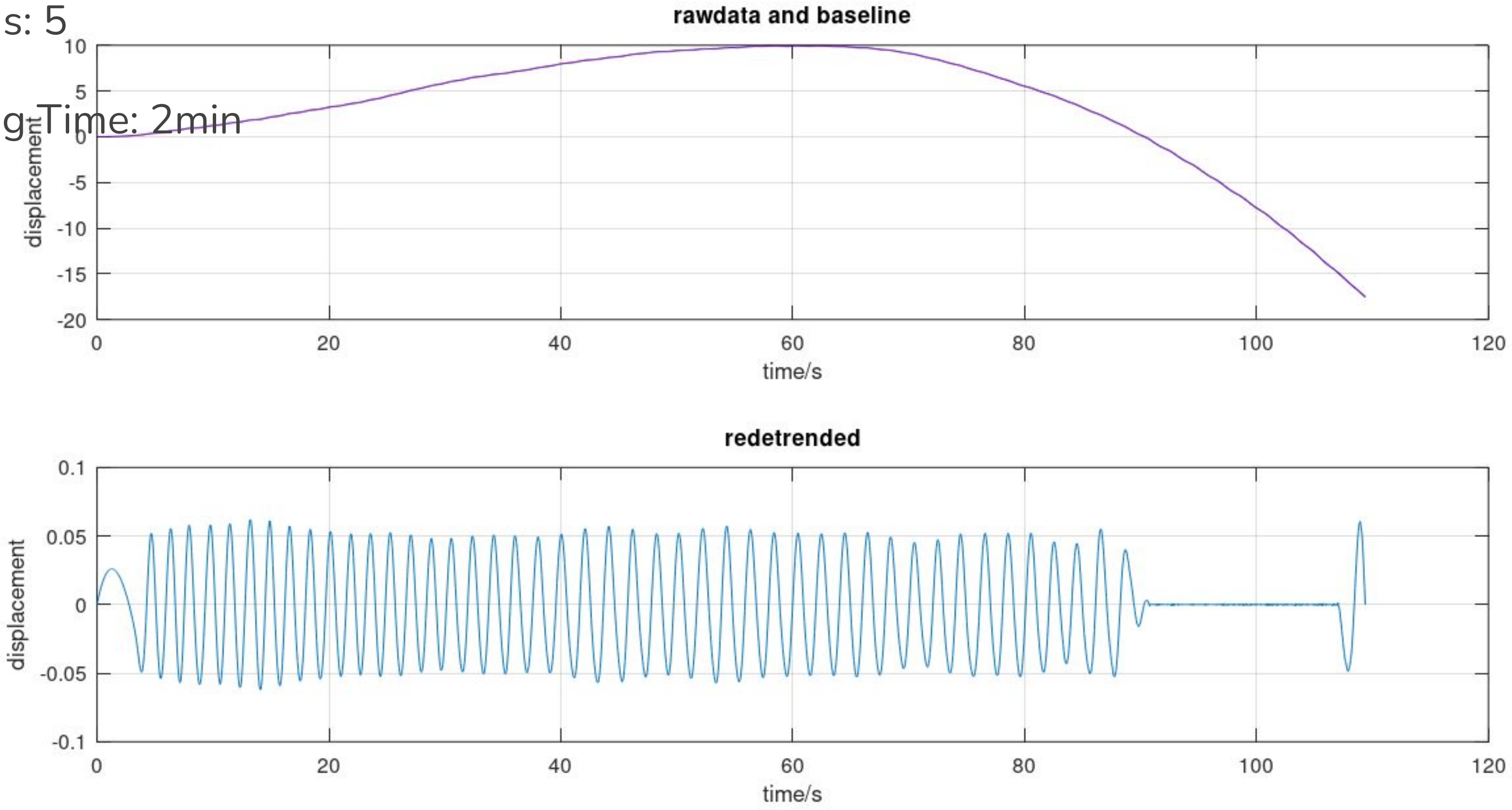
Sampling Time: 2min



Calculation Time: 5min

Residue error: 0.03
iterations: 5

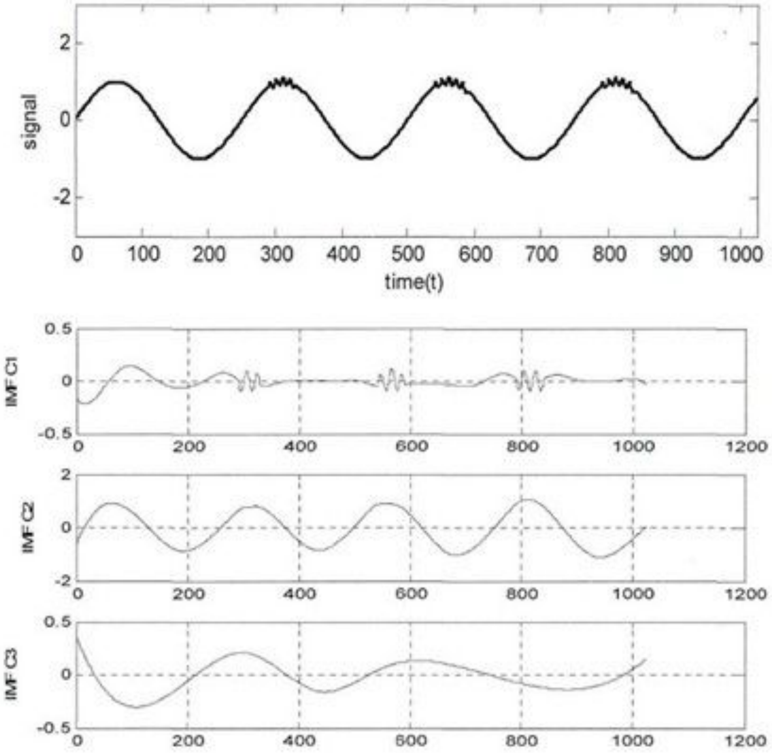
Sampling Time: 2min



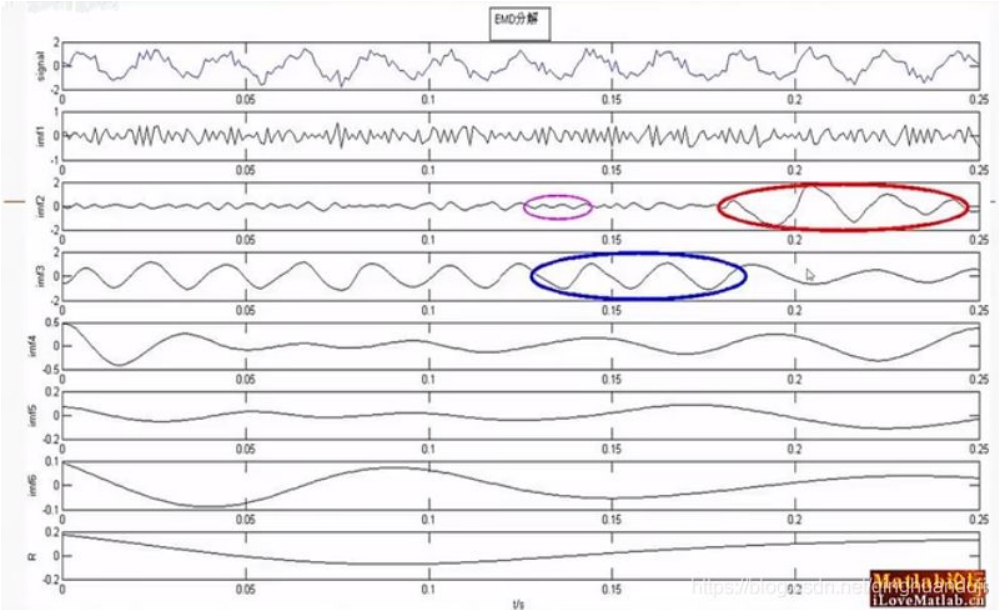
Calculation Time: 5min

Some Problems in EMD

Modal Mixing Problem



Endpoint Effect



Stop Conditions

Summary

	Savitzky-Golay Filter	Wavelet Decomposition	Empirical Mode Decomposition
Performance	Good	configure depended	Excellent
Computation Load	Good	Good	Bad
Adapativity	Good	Bad	Excelelnt

Other methods

Chromatogram baseline estimation and denoising using sparsity (BEADS) (OPT, convex optimization problem)

Smoothness Priors Approach Parameter Identification ，Regularized Least Squares Solution

variational mode decomposition

Thank you for listening