Table of Contents

MovingWindow

In this module, a moving (or sliding, or rolling) window algorithm for filtering/processing signals is implemented. It has been created in order to serve as a tool in 1D signal processing. There are many different situations (find envelopes, trends, smooth or even normalize a signal) where a sliding window along with a properly selected metric (mean, max, min, rms, std, etc.) will do a great job.

Getting Started

Dependencies

This module depends on three different packages:

- NumPy
- SciPy
- InputCheck

The first two packages are known to everyone interested in data science. Something like:

```
pip install <packageName>
```

or

```
conda install <packageName>
```

if you use Anaconda or Miniconda will probably do the job.

For the installation of the third package please read the corresponding README.md

Installation

To install this package just download the repository from GitHub or by using the following command line:

```
git clone https://github.com/ekarakasis/MovingWindow
```

Afterwards, go to the local root folder, open a command line and run:

```
pip install .
```

NOTE: *Do not forget the dot punctuation mark (".") in the end of the "pip install ." command*

Alternatively, you can add the "*root/MovingWindow*" folder to your project and add manually the module by using something like:

```
import sys
sys.path.append('../MovingWindow/')

from MovWin import MovingWindow
```

Run the Tests

To run the tests just go to the *root/MovingWindow/tests* folder, open a command line and write:

```
python test_all.py
```

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Documentation

Function Definition:

```
MovWin.MovingWindow(
    signal,
    windowSize=16,
    step=1,
    metric=np.mean,
    window='box',
    normalizedWindow=False
)
```

Parameters

- **signal** : *numpy.ndarray*
    - The actual signal we want to process.
- **windowSize** : *int*

- The size of the moving window. This input must have value greater than or equal to 2.
- **step** : *int*
  - Determines the overlap percentage of two consecutive windows. This input must have value greater than or equal to 1.
- **metric** : *<class 'function'>*
  - A function which is applied to each window (e.g. for a *moving average* the metric must be <np.mean>).
- **window** : *str*
  - The window type we want to apply. The allowed window types are:
    - box
    - gaussian
    - nuttall
    - hanning
    - hann
    - hamming
    - blackman
    - blackmanharris
- **normalizedWindow** : *bool*
  - When this flag is True, the selected window (e.g. hann) is normalized so as the sum of its elements to be equal to 1.

Raises

- **TypeError**
  - If any input has different type.
- **ValueError**
  - If any input has value different than the expected.

Returns

- **numpy.ndarray**
  - The function returns a moving window-based processed signal.

Example - Naive Signal Processing

Import Packages

```
import sys
sys.path.append('../')
sys.path.append('../../')

try:
    from MovingWindow.MovWin import MovingWindow
except ModuleNotFoundError:
    sys.path.append('../MovingWindow/')
    from MovWin import MovingWindow
```

```
import matplotlib.pyplot as plt
from scipy.signal import periodogram
import numpy as np

# adjusts the width of notebook
from IPython.core.display import display, HTML
display(HTML("<style>.container { width:85% !important; }</style>"))
```

Build a test signal

This signal will be used in the following examples.

```
fs = 128                     # <-- sampling frequency (Hz)
L = 32 * fs                  # <-- signal length
t = np.arange(0, L) / fs     # <-- time in seconds
f1 = 1.5                     # <-- 1st main frequency component of the signal (Hz)
f2 = 0.5                     # <-- 2nd main frequency component of the signal (Hz)

noise = np.array(
    MovingWindow(
        np.array(2 * np.random.rand(L) - 1) * 2, 7, 1, np.mean, 'box', False))
sinesig1 = np.sin(2 * np.pi * f1 * t)
sinesig2 = 0.75 * np.sin(2 * np.pi * f2 * t)

signal = sinesig1 + sinesig2 + noise  # <-- test signal
```

Define some useful functions

NOTE: These functions have been designed for the specific characteristics of the test signal.

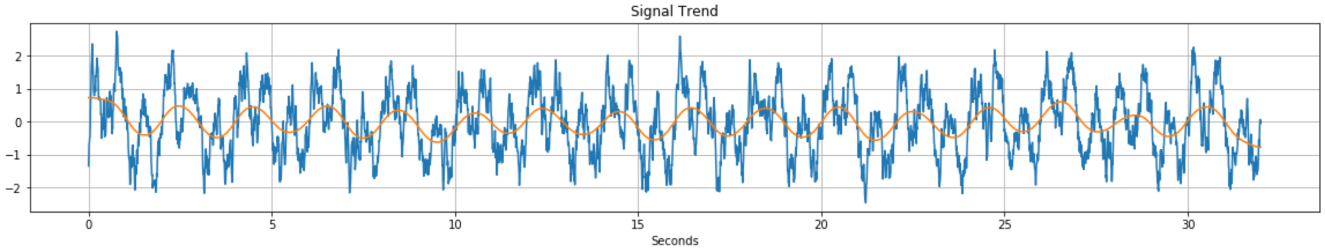
```
def UpperEnvelop(signal, fs):
    return MovingWindow(
        MovingWindow(signal, int(fs * 0.5), 1, np.max, 'box', False),
        int(fs), 1, np.sum, 'gaussian', True)


def LowerEnvelop(signal, fs):
    return MovingWindow(
        MovingWindow(signal, int(fs * 0.5), 1, np.min, 'box', False),
        int(fs), 1, np.sum, 'gaussian', True)


def Trend(signal, fs):
    return MovingWindow(signal, int(fs * 2), 1, np.sum, 'gaussian', True)


def Detrend(signal, fs):
    trend = Trend(signal, fs)
    return signal - trend


def Norm01(signal, fs):
```

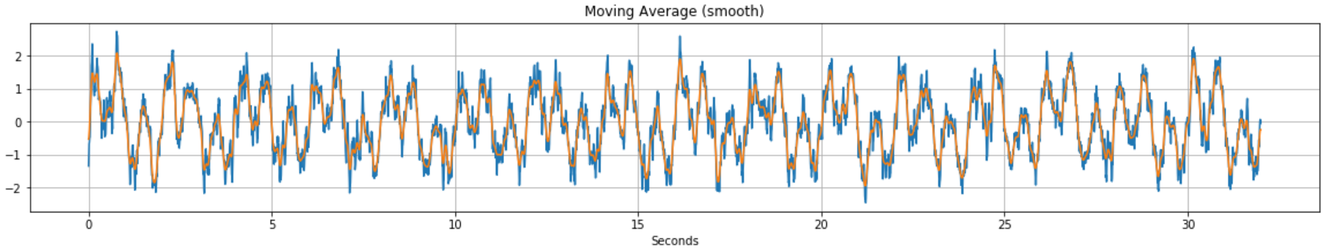
```
    signal_ue = UpperEnvelop(signal, fs)
    signal_le = LowerEnvelop(signal, fs)
    return (signal - signal_le) / (signal_ue - signal_le)


def Smooth(signal, fs):
    return MovingWindow(signal, int(fs * 0.2), 1, np.sum, 'gaussian', True)


# def nextpow2(x):
#     n = 1
#     while n < x: n *= 2
#     return n


def FFT(x, fs):
    Y = np.abs(np.fft.rfft(x))
    L = len(Y)
    Y = Y / L
    f = (fs / 2) * np.arange(L) / L
    return f, Y
```

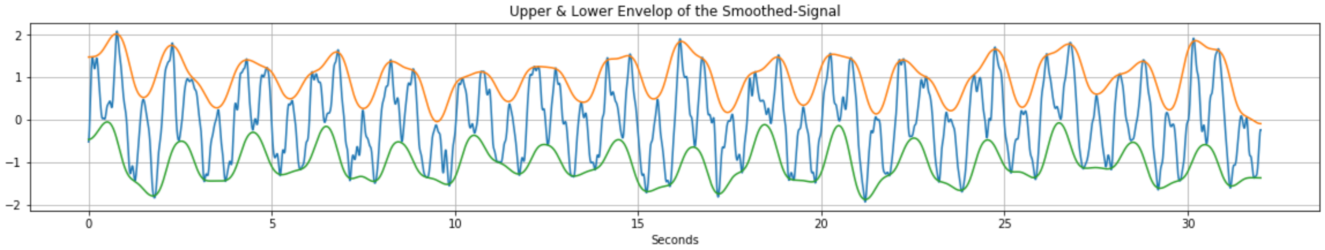
Naive signal processing and presentation of results

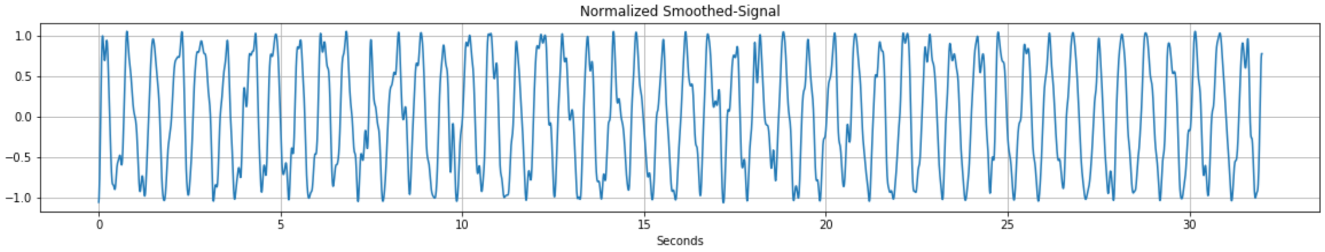
```
#
# =======================
# Naive signal processing
# =======================
#
trend = Trend(signal, fs)
signal_sm = Smooth(signal, fs)
signal_ue = UpperEnvelop(signal_sm, fs)
signal_le = LowerEnvelop(signal_sm, fs)
signal_nr = 2 * Norm01(signal_sm, fs) - 1
sig_smx3_nr = 2 * Norm01(Smooth(Smooth(Smooth(signal_nr, fs), fs), fs), fs) - 1

f1, Y1 = FFT(signal, fs)
f2, Y2 = FFT(sig_smx3_nr, fs)



#
# ================
# Plot the results
# ================
#
def Plot(axisXLst, sigLst, title='', xlabel='', ylabel=''):
    plt.figure(figsize=(20, 3))
    for X, Y in zip(axisXLst, sigLst):
        plt.plot(X, Y)
    plt.grid(True)
    plt.title(title)
    plt.xlabel(xlabel)
```

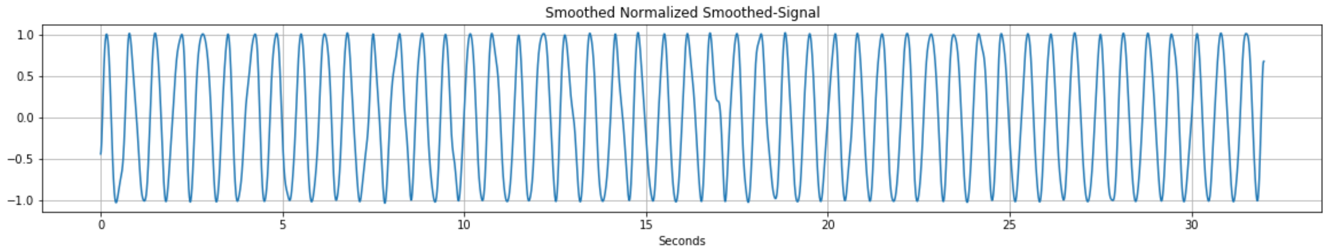
```
    plt.ylabel(ylabel)
    plt.show()


Plot([t, t], [signal, trend], 'Signal Trend', 'Seconds')
Plot([t, t], [signal, signal_sm], 'Moving Average (smooth)', 'Seconds')
Plot([t, t, t], [signal_sm, signal_ue, signal_le],
     'Upper & Lower Envelop of the Smoothed-Signal', 'Seconds')
Plot([t], [signal_nr], 'Normalized Smoothed-Signal', 'Seconds')
Plot([t], [sig_smx3_nr], 'Smoothed Normalized Smoothed-Signal', 'Seconds')

idx = range(100)
Plot([f1[idx]], [Y1[idx]], 'FFT', 'Frequency (Hz)', 'Amplitude')
Plot([f2[idx]], [Y2[idx]], 'FFT', 'Frequency (Hz)', 'Amplitude')
```

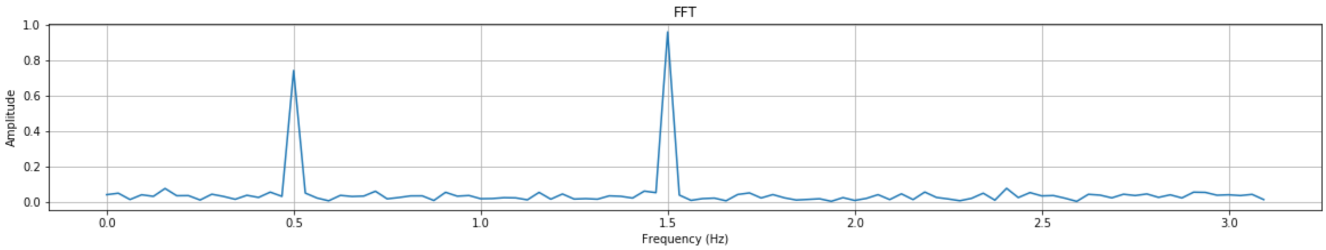


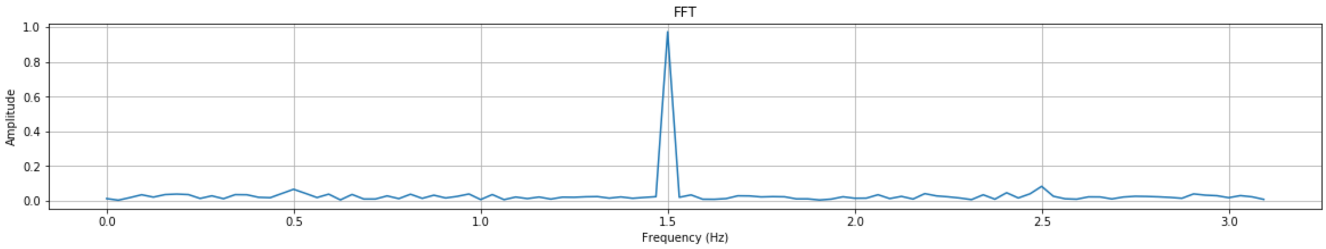












Example - Use lambda functions to define custom metrics

```
# build the rms metric using lambda function
rms = lambda x: np.sqrt(np.mean(np.power(x, 2)))

MovWinParams = {
    'signal': np.abs(signal),
    'windowSize': 20,
    'step': 1,
    'metric': rms,
    'window': 'box',
    'normalizedWindow': False,
}

signal_p = MovingWindow(**MovWinParams)
x = np.arange(len(signal_p))
Plot([x, x], [np.abs(signal), signal_p])
```